A Summary of Current Program and
Preliminary Report of Progress

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SWINE RESEARCH

of the

United States Department of Agriculture
and related work of the
State Agricultural Experiment Stations

This progress report is primarily a research tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs.

The summaries of research progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C. 20250

December 1, 1964

ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources and Facilities Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research
12. Plant Science and Entomology
13. Tobacco Research

ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First, there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

Agricultural Research Service (ARS)

1 - Agricultural Engineering
1 - Soil and Water Conservation
2 - Utilization -- Eastern
2 - Utilization -- Northern
2 - Utilization -- Southern
2 - Utilization -- Western
3 - Human Nutrition
3 - Clothing and Housing
3 - Consumer and Food Economics
4 - Market Quality
4 - Transportation & Facilities
7 - Animal Husbandry
7 - Animal Disease & Parasite
12 - Crops
12 - Entomology

Economic Research Service, (ERS)

4, 5 - Marketing Economics
5 - Farm Production Economics
5 - Resource Development Economics
5 - Economic & Statistical Analysis
5 - Foreign Development & Trade Analysis
5 - Foreign Analysis

Other Services

4, 5 - Farmer Cooperative Service (FCS)
4, 5 - Statistical Reporting Service (SRS)
6 - Forest Service (FS)

SUBJECT MATTER PROGRESS REPORTS

The other type of report brings together the U.S.D.A. program and progress for the following commodities or subjects:

3 - Rural Dwellings
6 - Forestry (other than Forest Service)
7 - Beef Cattle
7 - Dairy
7 - Poultry
7 - Sheep and Wool
7 - Swine
7 - Cross Specie and Miscellaneous Animal Research
8 - Cotton and Cottonseed
9 - Grain and Forage Crops
10 - Citrus and Subtropical Fruit
10 - Deciduous Fruit and Tree Nut
10 - Potato
10 - Vegetable
10 - Florist, Nursery & Shade Tree
11 - Oilseeds and Peanut
11 - Sugar
13 - Tobacco

A copy of any of the reports may be requested from Max Hinds, Executive Secretary, Animal and Animal Products Research Advisory Committee, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C.

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See also Cross Specie and Miscellaneous Animal Research report for:

Animal Biology: basic research on genetics, nutrition and physiology.
Engineering work applicable to farmstead planning including chore time standards, model layouts, and water supply.
Miscellaneous Diseases and their aspects such as serum, bloat, laboratory diagnosis, toxicology and pathology related to insecticides, biochemical effects of agricultural chemicals, poisoning by plants, and related programs.
Parasites: collection, index catalogue, removal of.
Beef Cattle, Horse, and Swine Insects: insecticides, residues, biological control, sterility, attractants, vectors of disease.
Meats - Processing and Products: chemical and physical properties, flavor, microbiology.
Animal Fats and Oils: composition, industrial uses.
Hides, Skins, and Leather: properties, modification, processing.

INTRODUCTION

This report on swine research covers work directly related to the production, processing, distribution, and consumption of pork. The information has been assembled from the organizational unit reports of the several divisions. This report does not include extensive cross-commodity work, much of which is basic in character, which contributes to the solution of not only swine problems but also to the problems of other commodities. Progress on cross-commodity work is found in the reports of the several divisions such as Soil and Water Conservation, Human Nutrition, Transportation and Facilities, Farm Production Economics, Foreign Development and Trade Analysis, and Cross-Specie and Miscellaneous Animal Research.

This report is devoted to the 14 "problem areas" shown in the table of contents. For each area there is a statement of (1) the Problem, (2) the USDA and Cooperative Program, (3) Program of State Experiment Stations, (4) a summary of Progress during the past year on USDA and cooperative work, and (5) a list of Publications resulting from USDA and cooperative work.

Swine research can be divided into three major categories, i.e., that supported by (1) Federal funds appropriated to the research agencies of the United States Department of Agriculture, (2) Federal and State funds appropriated to the 53 State Agricultural Experiment Stations, and (3) private funds allotted, largely by the swine industry, to research carried on in private laboratories or to support of State Station or USDA work. For all three categories it is estimated that about 800 scientists are engaged in research dealing specifically with the production, processing, distribution, and consumption of pork. Support of their work involves an annual expenditure of between 20 and 25 million dollars. This amounts to about 0.6% of the cash farm receipts from hogs and about 0.3% of the retail value of pork products. Of the 800 scientists engaged in swine research, approximately 14% are employed by the Department of Agriculture, 20% by the State Experiment Stations, and 66% by other universities, foundations, and private industry.

Research by USDA

Farm research pertaining to swine is conducted in the Agricultural Research Service divisions of Agricultural Engineering, Animal Disease and Parasite, Animal Husbandry, and Entomology. The work comprises investigations of breeding, physiology, nutrition, diseases and parasites, housing equipment, management and production influences on animal products. The work involves 70 professional man-years of scientific effort.

Nutrition, consumer, and utilization research pertaining to pork is conducted in the Agricultural Research Service divisions of Human Nutrition, Consumer and Food Economics, and Eastern Utilization. The work comprises investigations of composition and nutritive value; physiological availability of nutrients and their effects; new and improved methods of preparation, preservation, and care in homes, eating establishments and institutions; and with the processing phase involving slaughter, cutting, trimming, smoking, curing, and preparing for later use by consumers. The work includes considerable emphasis on chemical and physical properties of meat. Also, it is concerned with improved equipment and processes. The work in these divisions involves 22 professional man-years of scientific effort.

The utilization research in meat processing and products, animal fats and oils, and hides, skins, and leather which involves more than one species - and if done with one specie may be applicable to others - is discussed in "Cross Specie and Miscellaneous Animal Research" progress report.

Marketing and economic research pertaining to live animals and pork is carried on within four Services: Agricultural Research Service, Economic Research Service, Farmer Cooperative Service, and Statistical Reporting Service. The work comprises (1) physical and biological aspects of assembly, packaging, transporting, storing and distribution; (2) economic aspects of marketing costs, margins and efficiency, market potential, supply and demand, and situation and outlook; (3) cooperative marketing, and (4) consumer acceptance studies. The divisions in which the work is conducted are: Market Quality, ARS; Transportation and Facilities, ARS; Marketing Economics, ERS; Economic and Statistical Analysis, ERS; Marketing Division, FCS; Standards and Research, SRS. The scientific effort involved by these divisions amounts to 7 professional man-years.

Interrelationships among Department, State and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the Station. Cooperative work is jointly planned, frequently with the participation of representatives of the producers or industry affected. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators which frequently includes resources contributed by the interested producers or industry.

Including both cooperative and State Station projects swine research is carried in 47 of the 53 State Experiment Stations. The types of work to which the largest amount of effort is devoted include breeding, physiology, nutrition and management, diseases and parasites, marketing and economics, and utilization research on meats and animal fats. There is regular exchange of information between Station and Department scientists to assure that the programs complement each other and to eliminate unnecessary duplication.

Privately supported swine research emphasizes the solution of scientific production, processing, and marketing problems. Much of it utilizes the results of basic work done by State Station and Department scientists.

About one-third of industry's contribution to the research effort pertains to farm research. In contrast with the poultry industry where practically all breeding research is done by industry, very little is done by industry in beef, except the work of large firms like the King Ranch which developed the Santa Gertrudis breed. In the case of swine there is a real opportunity for increased participation by industry. The task of evaluating breeds, the performance of breeds in crossing, and the comparison of crossing systems will take more animals than are available at publicly supported experiment stations.

About equal to the farm research effort in the livestock industry, another one-third is in the utilization field. In contrast with the public research in basic work the industry program places strong emphasis on developmental activities and solving of immediate problems. The work of meatpackers is devoted to finding industrial utilization of by-products, quality control devices, improved formulation of products, improved handling and plant arrangement. Independent laboratories and foundations take on short time problem-solving for clients in the meat industry. Pharmaceutical firms carry on research on extraction of biologically active substances from meat by-products such as hormones from glands, and with the development of agents, such as antibiotics for use in meat processing.

The contributions of swine producers and industry to the work of the State Stations and the Department have been an important factor in the success of their research programs. Producers offer herds and facilities for testing products and practices used in production. Likewise, processors and retailers offer facilities and products for use by public research agencies. Many problems in the economics of marketing cannot be transferred to a laboratory, experimental plot, or other simulated situation. The results of economic research conducted cooperatively is of great value to industry, especially in cases where public research can provide comparison and analysis. Even large firms that have a research staff do not have access to the plants and records of competitors.

Examples of Recent Research Accomplishments by USDA and Cooperating Scientists

Zinc in the diet of the sow protects pigs from parakeratosis. Studies at Beltsville, Maryland, of zinc in colostrum and milk from sows indicated that the level of zinc in the diet of the sow may markedly influence the susceptibility of pigs to parakeratosis. Supplementation of ordinary sow diets during gestation and lactation did not increase the level of zinc in the colostrum but did hold the level of zinc in milk much above that from unsupplemented sows at 35 days lactation. Attempts to experimentally produce parakeratosis in pigs from sows receiving supplemental zinc were unsuccessful, while this condition was readily produced in pigs from dams on unsupplemented diets.

Diagnosis of Hog Cholera. Since the discovery, in 1904, that hog cholera was caused by a virus, there has been a continuing effort to devise a laboratory diagnostic procedure for this serious disease. Recently a method of identifying hog cholera virus in animal tissues by the use of immunofluorescence has been developed. The virus is grown in swine kidney cells and stained with a fluorescent stain. It is then examined under a special microscope to demonstrate the virus-infected cells. This test has proved about 98 percent efficient in detecting hog cholera in experimental animals. The efficiency of this test in diagnosing field cases of hog cholera is being investigated. The test should be of great value in the campaign to eradicate hog cholera from the United States.

Area Control of Hog Cholera with Inactivated Vaccines. Results compiled from a single county-wide pilot study area (Lowndes County, Georgia), using killed-virus vaccines, indicate that two 5-milliliter doses of vaccine, given one month apart, were effective in the control of hog cholera. Over a 2-year period (March 1962 to February 1964) approximately 60,000 swine were vaccinated in this manner. The killed-virus vaccines used had excellent immunizing properties. The advantage of killed-virus vaccine is that it is not a source of live virus which could be maintained in the pig for possible transmission to susceptible swine at a later time.

Ventilation of Livestock Buildings. Research in cooperation with State Experiment Stations has obtained much needed basic data on the heat and moisture given off by cattle, hogs, and poultry, and on the influence of building environment on production and feed consumption. The heat and moisture dissipation data are considered basic design data for ventilation systems of poultry, dairy, and swine buildings. They appear in design handbooks including the 1964 Guide and Data Book of the American Society of Heating, Refrigeration, Ventilating, and Air Conditioning Engineers, and are used by makers of ventilating equipment, prefabricated buildings and package buildings as well as by specialists advising farmers on their own construction. Building improvements resulting from the above research have contributed to the substantial rise in efficiency of livestock production that has occurred during the past decade.

"Hot" Processing of Hog Carcasses. Experimental results on processing "hot" hog carcasses directly from the killing floor indicate that this technique is feasible. Conventional processing of chilled carcasses requires approximately 118 hours from the killing floor to the finished product; the "hot" processing methods requires only 15 hours. Hot processing eliminates the need for a large and expensive chill cooler, reduces the holding cooler space requirements, and eliminates excess handling of carcasses and cuts in slaughtering and processing plants. Tests show that the new procedure causes no deterioration in

quality factors such as taste, tenderness and juiciness and the carcass yield is not affected. With approximately 80 million hogs slaughtered and processed in commercial facilities annually, the adoption of this procedure could save the industry several million dollars each year in reduced labor and facility costs.

New Facilities for Handling Meat and Poultry in New York City. As a result of studies by the Transportation and Facilities Research Division, ARS, an additional $40 million complex of facilities is being planned for handling meat and poultry, for which the New York City Board of Estimate has allotted $6.1 million for site acquisition and design. The facilities are being planned adjacent to the new $36 million fruit and vegetable facility that is under construction at Hunts Point and will replace the 14th Street and Brook Avenue Markets. Total annual saving in handling fruits, vegetables, meat, and poultry in new facilities is estimated to be almost $25 million.

I. FARM RESEARCH

SWINE - BREEDING

Animal Husbandry Research Division, ARS

Problem. Improvements in the heredity of swine depend on the intensity and accuracy of selection practiced in choosing breeding animals and on the choice of a mating system that maximizes the rate of genetic improvement. Crossbreeding swine for the production of market animals has so proved its value that over 90% of the pigs marketed in the United States are currently some kind of crossbreds. Research in swine breeding thus is faced with the dual challenge of developing foundation seed stock populations that yield maximum improvement for commercial production and also devising methods that fully utilize the genetic potential of available seed stocks for further increases from heterosis and hybrid vigor generally shown by crossbred pigs. It is essential that experimental work continue the development of genetic facts and practical methods that breeders can use to develop better and more efficient seed stock strains. Particular effort is needed on effective genetic means for efficient production of pork with more lean and less fat without sacrificing gains in other production traits.

USDA AND COOPERATIVE PROGRAM

This is a continuing program of basic and applied research conducted by geneticists and animal husbandmen to elucidate genetic principles and develop effective breeding systems that will result in further increases in the efficiency of swine with respect to productivity and carcass value. This is a coordinated research effort involving the USDA and several State agricultural experiment stations. Research is in progress at Beltsville, Maryland, cooperatively with the Montana Agricultural Experiment Station at Miles City, Montana, and at the Regional Swine Breeding Laboratory with headquarters at Ames, Iowa. The Regional Laboratory includes cooperative projects at State Agricultural Experiment Stations in Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Nebraska, North Carolina, Oklahoma, South Dakota, and Wisconsin. Investigations on genetic principles, selection, and breeding systems include work with swine and also with laboratory animals on important performance traits, their heritabilities, and their phenotypic and genetic correlations. The results of such studies provide the basis for emphasis given to different complex traits and the underlying factors in evaluating different systems for achieving genetic changes. Traits of major interest include productivity of dam, viability, growth rate, feed efficiency, carcass composition, and quality of meat.

Cooperative research with the Food and Drug Administration is in progress to investigate the response of "miniature" swine to further reduction in body size from selection and their usefulness for toxological tests as well as basic studies in nutrition and genetics.

The Federal scientific effort in this area totals 9.5 professional man-years. Of this number, 2.2 are devoted to genetics and interrelations of performance traits, 5.2 to selection and breeding systems, and 2.1 to program leadership.

A grant with the College of Agriculture, Poznan, Poland, provides for investigations on red blood cell and serum antigens to establish the mode of inheritance and relative frequencies of these antigens in certain breeds of swine. Its duration is for five years, 1962-1966, and involves PL-480 funds.

PROGRAM OF STATE EXPERIMENT STATIONS

Swine breeding research uses experiment station animals, herds of cooperating swine producers, and litters on tests in swine testing stations. Economic traits being considered include growth rate, feed deficiency, maternal ability, litter size, viability, and carcass yield and quality. Areas of investigation include estimation of genetic parameters, comparison of methods of selection and breeding systems, and evaluation of crossbreeding. In some instances, interrelationships of genetics and certain environmental factors such as housing, nutrition, and management are also being studied. Genetic parameters of interest include heritability (the degree which traits are influenced by genetic factors) of the above economic traits and the genetic and environmental relationships between these traits.

Much of the research on evaluation of breeding systems concerns the effectiveness of mass selection based on one or more of the economic traits. In addition, evaluation of recurrent selection to increase combining ability is being conducted. Meatiness of the carcass is one of the most important economic traits. Selection programs have recently been initiated to select for decreased backfat at market age. Crossbreeding in swine has been widely adopted by the industry. Research is in progress to determine the relative degrees of hybrid vigor resulting from crosses between specific breeds and strains and the value of selection within strains for the ability to combine well in crosses. Various systems of crossbreeding including crisscrossing, three-way crosses, and multiple breed crosses are being evaluated. Efforts are also under way to develop new breeds from crossbred foundations, and attempts are being made to maintain the superiority of crossbreds for every trait.

The North Central stations and Oklahoma conduct swine breeding research in cooperation with the USDA through the Regional Swine Breeding Laboratory with headquarters at Ames, Iowa.

The total research effort on swine breeding research by the State agricultural experiment stations is 23.6 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Genetics and Interrelations of Performance Traits

1. Genetic and phenotypic parameters. Skeletal data obtained on high-fat, low-fat, and control line Duroc and Yorkshire pigs showed Yorkshire pigs significantly exceeding Duroc pigs in both number of thoracic and lumbar vertebrae and number of ribs. Line differences in Yorkshires did not differ significantly, but in Durocs both low-fat and control line pigs significantly exceeded high-fat pigs in the two traits, indicating that upward selection for backfat thickness in Durocs definitely resulted in a reduction in both average number of vertebrae and average number of ribs. Sex differences were negligible in all lines. (AH a1-12)

In a study of sexual maturity, S-LL and S-BB gilts, representing two select strains currently being used in a reciprocal recurrent selection program, averaged approximately 18 days less in age at first estrus than their respective C-LL and C-BB control groups. These advantages in favor of the two select strains point in the same direction as those shown last year by S-BL and S-LB crossbred gilts over the same two control groups, and suggest that selection for specific combining has had the effect of reducing age at first heat in both crossbred and straightbred gilts produced by select straightbred females. (AH a1-13)

Efficiency of feed utilization expressed as weight gain per pound of feed and its relation to daily gain, daily feed consumption, percent lean cuts in the carcass, and backfat thickness was obtained from data on 108 straightbred and crossbred Yorkshire and Duroc pigs in individual feeding tests from about 85 days of age to 210 pounds average weight. Heritability estimates indicated that over half of the total variance in efficiency, growth rate, and feed consumption was accounted for by additive genetic effects. Genetic correlations among the five variables had rather large confidence intervals, but suggested important genetic interdependence for growth rate, feed efficiency, and backfat thickness. Positive genetic correlations were found between gain and efficiency (.32) and between gain and backfat thickness (.69) and a large negative (-.92) between efficiency and backfat thickness. (AH a1-10)

Feed efficiency, gain, and feed consumption from 42 to 154 days of age studied with data from 999 litters of pigs in six crops over a three-year period showed linear correlations of $-.28 \pm .03$ between efficiency and feed consumption and $.15 \pm .03$ between efficiency and gain. This latter value is lower than values generally observed with initial and final weight constant. This suggests that in age-constant tests fast growers may be less efficient due to increased maintenance requirements, while in weight-constant tests they reach a given weight in less time and thus save feed for maintenance. It appears from this that feed efficiency should be measured with weight held constant. Heritability of feed efficiency estimated from paternal half-sib differences among litter means was $.27 \pm .06$. (AH a1-22)

Data from 461 Yorkshire pigs with three levels of inbreeding (0, 33, and 49%) showed an interaction of sex with inbreeding. For noninbred pigs, the difference in weight at 154 days of age between barrows and gilts was 17.1 pounds. This difference became smaller as inbreeding increased. For each 10% increase in inbreeding, the decline in average weight at 154 days was 8.0 pounds for barrows and 5.7 for gilts. Average differences at 200 pounds liveweight between full-sib barrows and gilts (26 pairs) showed gilts to be nine days older and .19 inches longer with slower test gain (.2 lbs/day), less backfat (.14 inches), more loin eye (.46 square inches), and higher percent of ham and loin (1.9). (AH a1-23)

Efficiency of gain and phenotypic correlations among postweaning traits were investigated with data from 1,132 group-fed pigs sired by 283 boars and 184 boars fed individually. Phenotypic correlations of .36, -.24, and .05 between average daily gain and average test weight, daily gain and feed per pound of gain, and average test weight and feed per pound of gain, respectively, were obtained from the group-fed pigs. Multiple regression of feed per pound of gain on the other two variables accounted for 8% of the variance in efficiency. Of various equations developed to estimate efficiency those that included daily gain and daily feed consumption accounted for 94% of the variance in feed per pound of gain, while those that omitted daily feed consumption accounted for less than 23% of the variance. Phenotypic correlation showed feed per pound of gain decreasing as gain increased ($r = -.40$) and increasing as feed per day increased ($r = .63$). The results indicate that efficiency of gain cannot be estimated with much precision from observations that do not include average daily feed consumption. (AH a1-8)

Preliminary study of the relation of lean cuts to liveweight, carcass weight, and backfat probe with data from 101 barrows ranging in weight from 159 to 265 pounds indicated that either liveweight or carcass weight alone gave a fairly accurate estimate of pounds of lean cuts. On the other hand, backfat probe was the better indicator of percent of lean cuts. Multiple regression with weight and probe as independent variables was only slightly better than linear regression on the better variable in each case. Liveweight alone accounted for 82% of the variance in pounds of lean cuts, and backfat probe alone accounted for 56% of the variance in percent of lean cuts. This indicates that the most useful information on carcass composition is obtained with backfat probe when weight is held constant. (AH a1-20)

Heritability of backfat estimated from response to selection was .74. Other respective heritabilities based on data for 331 pigs using regression on dam and regression on midparent were: average daily gain, .17 and .22; weaning weight, -.17 and -.05; total score for desirability, -.10 and .17; and feed per pound of gain, .15 and .10. Genetic correlations of backfat were .70 with average daily gain, -.93 with total score, and -.46 with feed per pound of gain. Other genetic correlations were small. Correlated responses from selection indicate a genetic relation of .72 between backfat

and daily gain. It appears that reduction in backfat may reduce growth rate and efficiency of feed utilization. The repeatability of judges in scoring for meatiness was .76. (AH a1-21)

A study of muscle quality characteristics in the longissimus dorsi muscle in 87 Yorkshire and 55 Duroc pigs showed Yorkshires averaging higher in pH value, color-firmness quality scores, moisture, myoglobin, and fiber diameter; and lower in initial glycogen level and ether extract. Expressible moisture was similar for the two breeds. Pooled intragroup correlations of color-firmness quality scores were: with pH .35, with myoglobin concentration .25, and with expressible moisture -.17. Correlations of pH of the longissimus dorsi muscle with glycogen and myoglobin concentrations were -.30 and .34, respectively. In the Duroc breed, fiber diameter was correlated with ether extract and with percent moisture .36 and -.45, respectively. Nonsignificant correlations were observed among these traits in the Yorkshire breed and on an intragroup basis.

Heritability estimates indicated strong additive genetic influence (h^2 mostly above .50) on pH, expressible water, ether extract, percent moisture, myoglobin, and fiber diameter. Heritability was essentially zero for color-firmness quality score and initial glycogen content. Some of the higher genetic correlations within the Duroc breed were pH with myoglobin (.87 ± .20) and with fiber diameter (.88 ± .25), myoglobin with percent moisture (1.12 ± .14) and with ether extract (1.26 ± .33), and ether extract with percent moisture (.95 ± .05). In the Yorkshire breed genetic correlations with one exception (quality score with ether extract, -.79 ± .39) were generally small. (AH a1-10)

2. Pilot experiments. Selection for postweaning growth (18-42 days) in mice produced a more or less linear increase in growth which in the 17th generation was about six times the additive genetic standard deviation and about 43% of the original average growth. Heritability of growth was estimated at .24 ± .07 for males and .26 ± .08 for females. Growth in the selected population was about 3.5 g. greater than in the F_1 cross of the progenitor inbred lines. This suggests average dominance is in the direction of alleles favorable for growth but far from complete dominance. Crosses of the line selected for growth rate with an unselected inbred line over 20 generations of selection showed increases approximately one-half that achieved from mass selection and thus provided no definite evidence of nonadditivity of growth. Estimates of genetic correlation between growth rate and litter size have been positive. At the end of 22 generations of selection for growth rate, average litter size is 1.5 mice larger than at the start. The correlated response of litter size to selection for growth rate has amounted to one-tenth of a mouse per generation of selection with no evidence of reduction in the genetic correlation between growth rate and litter size. (AH a1-17)

3. Genotype-environment interactions. In the second year of selection for less backfat under different environmental conditions response to selection has been similar for backfat thickness, rate of gain, litter weaning weight, and feed efficiency. (AH a1-21)

The importance of heredity-environment interactions for carcass traits was studied with three kinds of crossbred pigs on three different diets with observations on 180 pigs for slaughter weight, carcass weight, backfat thickness, ham weight, five primal cuts, loin-eye area, carcass length, and estimated percents of lean, fat, and bone. Diets significantly influenced all traits except loin-eye area, loin weight, and ham weight. Breeding groups differed significantly for all traits except belly weight and liveweight at slaughter. Significant breed group x diet interactions was observed for ham weight, loin-eye area, and carcass length. (AH a1-17)

B. Selection and Breeding Systems

1. Selection for single traits. Backfat thickness in ninth generation high-fat, low-fat, and control line Duroc pigs averaged 2.00, 1.18, and 1.52 inches, compared with 1.46, .99, and 1.22 inches in seventh generation high-fat, low-fat, and control line Yorkshire pigs. Realized heritabilities now stand at .53 and .39 for high- and low-fat Duroc pigs, and .32 and .47 for high- and low-fat Yorkshire pigs. Carcass data obtained on samples of pigs slaughtered at about 220 pounds showed high-fat, low-fat, and control line Durocs averaging 2.56, 1.58, and 2.07 inches in backfat thickness; 27.1, 29.6, and 28.7 inches in length of carcass; 2.52, 3.65, and 3.43 square inches in loin-eye muscle area; 34.6, 39.8, and 38.1% in yield of lean cuts; 20.4, 12.6, and 15.1% in yield of fat cuts; and 11.8, 9.7, and 10.3% in yield of bacon. Seventh generation high-fat, low-fat, and control line Yorkshire pigs averaged 2.03, 1.27, and 1.56 inches in backfat thickness; 29.8, 29.8, and 30.1 inches in length of carcass; 3.48, 4.52, and 3.50 square inches in loin-eye muscle area; 37.7, 42.4, and 39.8% in yield of lean cuts; 15.9, 10.6, and 13.6% in yield of fat cuts; and 11.4, 10.0, and 11.0% in yield of bacon.

Data illustrating the effects of selection on the composition of individual cuts showed that dissected hams of ninth generation high-fat, low-fat, and control line Durocs averaged 6.2, 8.9, and 8.2 pounds in lean meat; 5.2, 4.0, and 4.2 pounds in fat; and 1.1, 1.5, and 1.3 pounds in bone. The hams of seventh generation high-fat, low-fat, and control line Yorkshire pigs averaged 8.0, 10.5, and 8.8 pounds in lean meat; 4.0, 3.5, and 3.8 pounds in fat; and 1.3, 1.5, and 1.4 pounds in bone. These results show quite clearly that the selection practiced for backfat thickness has brought about rather marked changes in both total weight and lean to fat ratio of the pig's hams, with the hams of Yorkshire pigs averaging more lean meat, less fat, and less bone than those of similarly selected Duroc pigs. (AH a1-12)

Comparisons between lines selected for a single trait and a control line showed after three generations little evidence of real differences in efficiency, 154-day weight, backfat thickness, and production index. However, disease problems in all herds resulted in rather small selection differentials. (AH a1-22)

Ten generations of selection for reduced backfat in a Duroc line produced 200 pound pigs in 1963 with an average backfat of 1.21 inches as compared with an average of 1.42 inches in 1953. Selection differentials averaged .14 of an inch over the 10-year period. Carcass length and loin-eye area increased as backfat was reduced. (AH a1-9)

Meatiness in one herd has responded to individual selection for backfat thickness and progeny testing for carcass traits. Average changes per year amounted to +.3 inches in body length, -.04 inches in backfat thickness, +1.6% in ham and loin, and +.22 square inches in loin-eye area. (AH a1-22)

Four generations of mass selection for reduction in backfat thickness show average achievement from selection amounting to about one-third of the amount selected for, with greater progress in the first two than in the last two generations. Average backfat thickness at 175 pounds in the initial herds was 1.10 inches and after the fourth generation of selection it was .91 inches. Analysis of data from the first two generations of selection suggested a slight decrease in daily gain while sow productivity, ham index, percent lean cuts, pounds of lean per day of age, and fat trim showed little or no change. (AH a1-21)

2. Selection for combining ability. Litters produced by two groups of straightbred females (BB and LL) selected on the basis of their cross progeny performance exceeded control strain litters by 1.3 and .7 pigs or by 16 and 8% in litter size at weaning, and by 28 and 55 pounds or by 8 and 16% in litter weight at weaning. Litters produced by single cross females (BL and LB) exceeded control litters by 1.6 and 1.7 pigs or by 24 and 25% in litter size at weaning and by 76 and 96 pounds or by 31 and 38% in litter weight at weaning. Single cross litters generally showed greater advantages over control line litters for both litter size and litter weight at birth and at weaning than was shown by single cross litters in earlier years, suggesting that the amount of heterosis shown by these traits is increasing as selection for specific combining ability progresses. (AH a1-13)

In the Miles City project, sixth cycle single cross pigs produced by reciprocally crossing fifth cycle Montana No. 1 and Yorkshire animals exceeded Montana No. 1 control strain pigs by .36 pounds or by 24% in daily gain from weaning to a final weight of about 225 pounds. This advantage for crosses is slightly greater than that shown by fifth cycle crosses. (AH a1-11)

Progeny of purebred and crossbred sires were compared for performance in the feedlot and for carcass traits. Variances of progeny performance were similar for both kinds of sires and indicate that use of crossbred sires did not increase variation among progeny. In general, progeny of crossbred sires performed at about the same level as those sired by purebreds from parental breeds used to make the crossbreds. (AH a1-17)

In an experiment designed to evaluate sires on the basis of their purebred and crossbred progenies, the ranking of contemporary sires was somewhat altered for the two kinds of progeny. This suggests that specific combining ability was present and perhaps of sufficient magnitude and frequency to justify its utilization in a breeding program. (N.C.)

Selection for combining ability among three lines has shown improvement. Over the past four years all tested sires have produced pigs which averaged at 200 pounds over 4 square inches of loin-eye area and less than 1.43 inches of backfat. Single cross gilts and purebred gilts farrowing single cross litters both had larger litters than the controls. There was some evidence of loss of heterosis by the control line which appears to be approaching equilibrium. (AH a1-8)

3. Development and evaluation of inbred lines and crosses. Data on 173 litters from four one-sire lines and 97 litters from a two-sire line of Montana No. 1 swine maintained at Miles City, Montana, from 1947 through 1954 showed the one-sire lines declining in all litter traits studied, with the linear regressions on years averaging -.22 and -.34 pigs for litter size at birth and at weaning and -.4 and -9.7 pounds for litter weight. The corresponding regressions for the two-sire line were -.08 and .02 pigs and -.3 and .5 pounds for litter size and litter weight, respectively. The positive values for the two-sire line point in the opposite direction from the inbreeding decline expected from the calculated regressions on inbreeding and the inbreeding increase per year, while the negative values obtained for the two sets of lines were from about one-half to three-fourths as large as the corresponding decline expected on this basis. (AH a1-11)

A miniature line of swine has been developed from animals obtained in the wild state from Catalina Island, Alabama, and Louisiana in 1949 and from Guam in 1958 with continuous selection for reduced size. Liveweight has been reduced by about 30% and present expected weight at 140 days of age is about 40 ± 20 pounds. These animals at one year of age are about one-half the size of conventional pigs the same age. Actual reduction in 140-day weight averaged about 3.2 pounds per generation from 1950 through 1961. Estimates of heritability increased from 16% to 41% after the introduction of stock from Guam. There is no evidence that response to selection has diminished in recent generations. (AH a1-17)

Matings between two inbred lines of Yorkshires inbred rapidly from four samples of superior germ plasm produced crossbred progeny superior to both lines for litter size at weaning and weight at 154 days of age. (AH a1-23)

Inbreds and top crosses with variable relationship to the inbreds produced in a "convergent improvement" breeding system over 10 years provided estimates of the influence of inbreeding on various traits. In agreement with other studies, inbreeding depressed litter size, viability, and growth rate but had little effect on carcass traits measured at 200 pounds live-weight. (AH a1-9)

Evaluation of samples from the Yorkshire breed by rapid inbreeding, line testing in crosses, and recombination in lines permitted early sorting among lines for desirable total performance. The lines performed satisfactorily and line differences for several traits were observed. (AH a1-9)

4. Environmental influences as related to performance. Repopulation of a herd by a modified "specific pathogen free" technique in 1961 led to a lower incidence of disease, improved reproductive performance, some reduction in mortality, and improved growth rate primarily from the reduction of the number of runt pigs. A gradual increase in disease level has occurred with Pasteurella, Corynebacterium, and Bordetella identified as present in the herd. (AH a1-22)

A significant growth stimulus was observed when Auero S-P 250 premix was added to the ration for the first four to six weeks after weaning. There was a carryover effect through the finishing period and a small improvement in efficiency which produced slightly cheaper gains from weaning to market weight. (AH a1-8)

5. Gene pools. A gene pool of the older breeds will be completed in 1965 when the Large Black and Hereford are brought in. Several samples recently added include the Mule Foot, Guinea, and European Wild hog. The average performance of the two lines in this gene pool has been very satisfactory with respect to litter size, growth rate, average age at puberty, and backfat thickness. Arrangements are now underway to establish a gene pool of the new or more recently formed breeds. (AH a1-20)

6. Crossbreeding and heterosis. Flushing straightbred and crossbred gilts from puberty to second estrus increased the average ovulation rate by 2.9 ova, but produced only a slight increase in the number of embryos surviving at 28 days gestation. Crossbred gilts (YD and DY) averaged about seven days younger at first estrus than straightbred (DD and YY) gilts. Age at puberty and response to flushing by Yorkshire (YY), Duroc (DD), and crossbred gilts (YD and DY) showed crossbreds exhibiting first estrus seven days earlier than straightbreds (DD = 212, YY = 217, DY = 205, and YD = 210). Ovulation rates and embryo survival showed no conclusive differences between the two kinds of gilts with overall average estimates of 14.2 ova at second estrus and 10.6 embryos at four weeks gestation. (AH a1-20)

In reciprocal crosses between the Landrace and the Poland China breeds, Landrace sows produced larger litters and smaller pigs at birth, 56, and

154 days of age. Performance of crossbred sows (LP and PL) mated to Duroc boars showed maternal influence in favor of Poland China mothers for litter size and pig weight at all three ages. Another reciprocal cross between crossbreds (LP and PL) and Durocs (DD) showed crossbred dams superior to Durocs for litter size and pig weight. Pigs from Duroc sows were shorter and had more backfat. These results indicate that a crossbreeding program should include at least three breeds to obtain hybrid vigor in both the dam and the pigs. (AH a1-21)

C. Performance and Progeny Testing

The Wisconsin Swine Selection Cooperative completed its 19th year of continuous on-the-farm testing in 1963. This program resulted from and has been based on findings in the Regional Swine Breeding Laboratory. It included 3,753 pigs farrowed in 359 litters in 1963 with 2,922 raised to five months of age. Comparison of averages in 1955 with those of 1963 shows that average loin-eye area had increased from 3.89 to 4.31 square inches and average backfat had decreased from 1.74 to 1.39 inches. In 1955, no pigs had less than 1.39 inches of backfat and only five had more than 4.31 square inches of loin eye. (AH a1-10)

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

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Peters, W. H., Hetzer, H. O., and Kincaid, C. M. 1963. Age at puberty and its influence on sow productivity. Annual Meeting, North Atlantic Section, ASAS, Morgantown, W. Va., Mimeograph. (AH a1-13)

Rahnefeld, F. W., Boylan, W. J., Comstock, R. E., and Singh, M. 1963. Mass selection for post-weaning growth in mice. Genetics. 48:1567-1583. (AH a1-17)

Salmela, A. B., Rempel, W. E., and Gates, C. E. 1963. Reaction of three kinds of single-cross pigs to three levels of feed intake. II. Carcass characteristics. J. Animal Sci. 22:886-889. (AH a1-17)

Turner, J. W. and Whatley, J. A. (Jr.). 1964. Predicting efficiency of gain in swine. (Abstr.) J. Animal Sci. 23:307. (AH a1-8)

Selection and Breeding Systems

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Short, R. E., Zimmerman, D. R., and Sumption, L. J. 1964. Heterotic influence on reproductive performance in swine. (Abstr.) J. Animal Sci. 22:868. (AH a1-20)

Zoellner, K. O., Lasley, J. F., Tribble, L. F., and Day, B. N. 1963. Selection for thinner backfat in swine. Mo. Agr. Exp. Sta. Res. Bull. 831. (AH a1-21)

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SWINE - PHYSIOLOGY
Animal Husbandry Research Division, ARS

Problem. Continued improvement in efficiency of swine production is dependent on new information regarding the physiology of growth and reproduction as well as environmental adaptation. Particularly in the field of swine fertility, considerable knowledge is needed regarding the development of artificial insemination including semen and ova preservation and storage. Fertility problems in boars and sows seriously plague the efforts of the industry to produce pork at lowest cost. Development of new genetic aids for improvement of swine requires additional understanding of the physiological processes, particularly those involved in the growth and production of high quality lean meat.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by physiologists, biochemists, and animal husbandmen on basic and applied problems in the physiology of reproduction, artificial insemination, and the physiology of growth and development, particularly with respect to the mechanisms involved in fat deposition, muscular development, and inborn metabolic differences. Research in progress at Beltsville, Maryland, is aimed primarily at the development of basic knowledge about swine physiology from the study of animals with contrasting genetic differences. Cooperative studies are also included in projects of the Regional Swine Breeding Laboratory at Missouri, Nebraska, and other cooperating stations as opportunities arise with respect to personnel and facilities.

The Federal scientific effort on research in this area totals 2.4 man-years. Of this number, 0.3 is on physiology of reproduction, 1.8 on physiology of growth and development, and 0.3 on program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

Much of the current program of research in this area is based on the thesis that increased reproductive efficiency in swine is dependent primarily upon an understanding of the nutritional and physiological influences on variability of ovulation rate and embryonic survival. Fundamental studies are underway designed to yield information on endocrine events occurring at the time of ovulation, and physiology of the uterine tract conducive to maximum embryonal survival. The effect of the level of nutrition at various stages of growth and development on ovulation rate and embryonal survival is also being studied.

Artificial insemination shows considerable promise in swine as it has in other species. Problems peculiar to swine must be solved, however, before the technique has practical application. Swine spermatozoa are relatively shortlived *in vitro*, and the volume and concentration of the ejaculate

are quite variable. These and other problems under study include the effects of the accessory glands on semen quality, and yield and composition of sow's milk and the effect of lactation stress on subsequent reproduction.

Stress factors under study include high and low ambient temperature, optimum temperature and humidity at different stages of development, and interrelationships of environmental temperature with nutrition and environment. The effects of cooling of males and females on conception rate and prolificacy are also being investigated.

Additional studies in this area, including design of housing and equipment, are being conducted in cooperation with Agricultural Engineering including a new regional project, NC-72, Swine Housing Environment.

State stations are investigating the influence of inbreeding and crossbreeding on physiological mechanisms affecting growth and fertility. One station is studying differences in carcass characteristics between barrows and gilts with particular reference to time and rate of development, and the influence of feeding low levels of hormones on sex-influenced growth pattern. Extensive basic research is concerned with the nutrition and physiology of the developing swine fetus. Changes in total serum protein and serum protein electrophoretic patterns during fetal development are being investigated and histological changes of the gastrointestinal tract as they occur during development of the fetus are being characterized.

The total State scientific effort devoted to swine physiology research is 11.8 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Physiology of Reproduction

1. Synchronization of estrus. Effective synchronization of estrus has been achieved by feeding a synthetic non-steroid compound (1-α-methylallythiocarbamoyl-2-methylthiocarbamoylhydrazine, ICI 33,828) to gilts. About 85% of the animals receiving .79 mg. of this compound per kilogram of weight expressed estrus from five to seven days after treatment was stopped. Conception rate was 70% and no adverse effect on ovarian function or fertility was observed. The average number of embryos observed on autopsy at 16 to 49 days gestation was 9.9. Further study is needed on this compound, but it appears that this work offers for the first time the possibility of a practical way to utilize artificial insemination in swine for breeding and farrowing on a fixed time schedule. (AH a1-19)

2. Factors influencing estrus and fertility. Implants of progesterone and estrogen on 11th day after mating produced a slight improvement in embryo survival, but a second similar trial with gilts implanted on the 7th day after mating showed no improvement over controls. In another experiment with 117 females, intramuscular injection of pregnant male

serum (PMS) and human chorionic gonadotrophin (HCG) induced superovulation and increased the average number of living embryos in gilts. Respective average ovulation rates and numbers of living embryos per litter were 23.8 and 8.8 for five treated gilts in comparison with 10.7 corporea lutea and 8.8 embryos for 13 controls. In a third experiment fertilized ova moved from the oviducts into the uterine horn from 66 to 90 hours after the onset of estrus. This was from 36 to 60 hours after estimated time of ovulation. Recovery of 83% of the ova from 55 females at intervals of time ranging from 30 to 108 hours after onset of estrus provided information on embryo development and transport which can be used for more effective study in this area. (AH a1-21)

Energy levels and method of restricting energy intake for gilts during the breeding season which produced average daily gains for four treatments of .44, 1.37, 1.42, and 2.01 per head per day showed respective averages per gilt of 14.1, 15.8, 15.4, and 15.5 ovulations. This indicates that the group with the lowest gain was the only one showing an adverse effect on ova production. Method of feeding, individual versus group, had little influence on ovulation rate. (AH a1-20)

B. Physiology of Growth and Development

1. Physiological differences under genetic control. Basic information to serve as a foundation for further research in swine physiology was obtained from pigs in six lines of Durocs and Yorkshires selected for backfat thickness over nine and seven generations, respectively. Average backfat thickness for these lines ranged from about 1.0 inch to over 2 inches. Weights were taken for liver, kidney, heart, pancreas, thyroid, adrenal, pituitary, stomach, and small intestine. Small intestine length and blood glucose levels were also measured. The thyroid and pituitary glands in the Durocs were significantly smaller than in the Yorkshires. However, the Yorkshires had significantly smaller pancreases, livers, adrenals, stomachs, and small intestines. In both breeds the size of the heart decreased as the amount of backfat increased. The weight of the pancreas in selected lines of both breeds was larger than the controls. Yorkshires averaged approximately one more vertebra and one more rib than Durocs. The incidence of stomach ulcers was 37.5%. These data indicate that selection has introduced physiological differences which can provide a sound basis for specific investigations of some genetically controlled physiological processes and their relation to productivity. (AH a1-19)

2. Gastrectomized pigs. In cooperative exploratory work with the National Institutes of Health, gastrectomized swine were used to study the influence of the absence of the stomach on degenerative changes in the central nervous system similar to those noted in human patients afflicted with amyotrophic lateral sclerosis. Ten pigs were gastrectomized. Six survived and showed clinical symptoms that suggested involvement of the central nervous system. Histological examination of tissue from the central nervous system of one pig showed no apparent differences from controls.

Clinical observations 20-24 weeks postgastrectomy included hypersensitivity, persistent tremor, spastic paralysis, unsteady gait, and adducted hind legs. All animals exhibited either transitory or permanent arrest of growth associated with the above clinical symptoms. A progressive development of both hypochromic and microcytic anemia was observed. This suggests that utilization of iron may have been a major factor in the overall response of these animals to gastrectomy. (AH a1-19)

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Physiology of Reproduction

Day, B. N., Romack, F. E., and Lasley, J. F. 1963. Influence of progesterone-estrogen implants on early embryonic mortality in swine. J. Animal Sci. 22:637-639. (AH a1-21)

Gibson, E. W., Jaffe, S. C., Lasley, J. F., and Day, B. N. 1964. Reproductive performance in swine following superovulation. (Abstr.) J. Animal Sci. 22:858. (AH a1-21)

SWINE - NUTRITION AND MANAGEMENT
Animal Husbandry Research Division, ARS

Problem. The changing demands of the consumer for pork with a high proportion of lean are requiring major changes in the nutrition and management of swine. Furthermore, the use of materials other than lard has greatly reduced the demand for fat-type hogs. Along with the change in genetic makeup which must be made, basic facts concerning metabolic functions require investigation, and the basic nutritional factors which influence growth and carcass composition need to be identified and evaluated. These require information on quantitative and qualitative requirements at various growth stages and the changes in requirements to adjust for altered levels of other nutrients or modified environment. To meet the competition of other foods, including other meats, the nutrition and management of swine must constantly be aimed at improvement of feed and labor efficiency.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by biochemists, nutritionists, and animal husbandmen investigating basic and applied problems in swine production related to nutrition, metabolism, and management. Work is in progress at Beltsville, Maryland, and cooperatively with the Agricultural Engineering Division and the National Institutes of Health, as well as through informal collaborative agreements with the Food and Drug Administration and the Southern Utilization Research and Development Division. These studies contribute to the establishment of nutrient and mineral requirements and the relation of different components of the diet to each other; to the development of more efficient and economical rations; to the relation of genetic differences to dietary requirements; and to the role swine may have as an experimental animal for the investigation of health and dietary problems in man.

The total Federal scientific effort in this area amounts to 7.8 professional man-years. Of this number, 2.0 are devoted to digestion and metabolism, 0.5 to concentrates, evaluation, and utilization, 1.5 to feeding methods, 2.0 to nutrient requirements, 1.0 to management practices and equipment, and 0.8 to program leadership.

PROGRAM OF STATE EXPERIMENT STATIONS

The States are engaged in both basic and applied research in swine nutrition. This research is concerned with the determination of nutritive requirements of swine at various stages of growth for specific amino acids, minerals, vitamins, protein, and energy and the changes in these requirements that result from altered levels of any of these nutrients. Other aspects are concerned with the determination of digestibility coefficients, absorption and retention, effect of diet on antibody production, and the use of feed additives such as hormones, enzymes, high copper levels, and antibiotics to improve growth and feed efficiency.

The requirements of the baby pig are being studied in order to develop economical practical liquid or dry starter rations and to investigate the effect of dietary ingredients on the palatability of baby pig rations.

Studies are in progress to determine the value of forage as an economical mineral, vitamin, and protein source as well as the utilization of these high roughage diets as a means of restricting feed intake of growing or gestating swine. Consideration is given to the effects of the variation in fiber levels in the ration on the growth rate and carcass quality, the nutritive requirements of pigs on dry lot versus those on pasture, and the effect of different forage pastures and dry lot feeding during gestation on number and weight of pigs at birth and weaning.

Other aspects of swine nutrition are concerned with improving the nutritional quality of rations utilizing locally grown feedstuffs by vitamin, amino acid, enzyme, or antibiotic supplementation.

The ways of managing the swine enterprise for more efficient operation are being investigated. Special attention is given to methods and levels of feeding gestating and lactating sows, management of suckling pigs, age of weaning, and the relative merits of pasture or drylot feeding.

Total research effort on swine nutrition and management is approximately 35.9 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Digestion and Metabolism

Effects of energy level on pigs with genetic differences in performance, type, and breed. The response to different levels of energy by Duroc and Yorkshire lines selected over several generations for either maximum or minimum backfat was measured with individual feeding trials and physical separation of carcasses from pigs ranging in age from 90 to 400 days. The absolute weights of fat and lean up to 220 days of age were linear for all groups. Restricted energy intake for high-fat lines in both breeds reduced the accumulation of fat but had no influence on lean, while in low-fat lines restriction of energy reduced the deposition of both fat and lean. This indicates that improvement of carcass composition by limited feeding will depend on the genetics of the pigs involved. The average ages at which pounds of fat exceeded pounds of lean in the carcass were as follows: low-fat Yorks at both energy levels, 39 weeks of age; high-fat Yorks and low-fat Durocs on restricted energy, 34 weeks of age; high-fat Yorks and low-fat Durocs on normal energy, 22 weeks of age; and high-fat Durocs on normal energy, 18 weeks of age. Balance trials at 90 days of age showed that pigs on the reduced energy level generally retained more nitrogen per unit of retained energy than pigs on full feed. The high-fat Duroc line was exceptional in that no difference was observed in nitrogen retention between nutrition levels. This line was also lowest in nitrogen retention

(3.73 mg./kcal.) and least efficient in feed utilization (2.79 kg.feed/kg.wt. gain) while the low-fat Durocs had the highest nitrogen retention rate (4.75 mg.N/kcal.) and were most efficient (2.45 kg.feed/kg.wt.gain). The two York lines were intermediate. (AH a3-18)

B. Concentrates - Evaluation and Utilization

Cottonseed meal. Shortly after discontinuance of work on improving the safety and use of cottonseed meal as swine feed (AH a3-16), the Southern Utilization Research and Development Division requested evaluation of cottonseed meals produced by extracting the oil with an azeotrope mixture of solvents, and for help in screening for toxic meals from commercial production. Preliminary pilot studies were done which characterized these new experimental meals as having high nutritional value (equivalent to soybean meal) and very low toxicity, while four of seven commercial meals were identified as toxic. A new project was activated to allow further testing of the azeotrope meals as well as review and testing of detoxification methods. (AH a3-19)

C. Feeding Methods

Limited feeding - gilts and sows. Results of previous studies in which nutrient intake was limited by dilution with high-fiber ingredients showed advantages from restricted diet in terms of superior reproductive performance which were largely nullified by inability to prevent excessive feed wastage. As restricted feeding seemed to offer a better solution to the problem, this work was revised to compare three levels of feed intake during the gestation period. Three levels of the standard Beltsville gestation diet, 6.0, 4.5, and 3.0 pounds per head per day, were fed to gilts in groups throughout gestation. No gilts on the intermediate level (4.5 pounds per head per day) weaned less than seven pigs, while some of those on both the high and low levels lost all their pigs and others weaned only a few. For groups of gilts receiving 6.0, 4.5, and 3.0 pounds of feed per head per day the average number of pigs weaned was 7.25, 9.70, and 6.70, respectively. These results indicate that reproductive performance may be improved by moderate restriction of feed intake during gestation, but either severe restriction or too much feed may be detrimental. This also suggests that individual feeding would be useful to insure proper feed intake by each animal and thus avoid over and under consumption by certain individuals when group feeding is practiced. (AH a2-5)

D. Nutritional Requirements - Trace Mineral Requirements and Interrelationships

1. Dietary zinc increased zinc content of sows' milk. Previous work at Beltsville indicated relatively high zinc content of sows' milk and colostrum in comparison with these secretions from the human, cow, and ewe. Further work in this area included comparison of a standard gestation diet containing 73 or 173 ppm of zinc and a standard lactation diet with 47 or

147 ppm of zinc. Level of zinc was high (97 ppm in fat-free dry matter) in first colostrum regardless of dietary zinc. The zinc content of milk from sows on low zinc diet declined rapidly in the first 24 to 48 hours, then maintained a fairly stable level and averaged at 35 days lactation 59 ppm in fat-free dry matter. Milk from sows on the high level of dietary zinc maintained a level of zinc nearly equal to that in first colostrum and averaged at 35 days lactation 92 ppm in fat-free dry matter. (AH a3-12)

2. Iron content of milk and colostrum of sows. A study of the iron content of sows' colostrum and milk and possible effect of oral supplementation of sows with various iron compounds on level of iron in mammary secretions has been initiated at Beltsville. A control group of 12 sows and a supplemented group of 12 which received the same diet plus 900 mg. of iron as ferrous fumarate/lb. of diet supplied colostrum and milk for assay. On a total dry matter basis, colostrum averaged 6.5 ppm regardless of dietary iron ingested. Mean figures for 35 day milk also based on total dry matter were 4.82 ppm for unsupplemented sows and 8.14 ppm for the supplemented sows. (AH a3-12)

3. Additive effect of calcium and phosphorus on utilization of dietary zinc. Two factorial experiments on interrelations of calcium, phosphorus, and potassium as they affect utilization of zinc were completed with male albino weanling rats. Criteria used were: rate of gain; feed efficiency; zinc content of liver, kidneys, bone, and hair; and serum alkaline phosphatase. Dietary levels of minerals tested were as follows: Ca, 1.2% and .3%; P, 1.2% and .3%; and K, .65% and .1%. No apparent relationship was noted between potassium levels tested and utilization of zinc. The principal conclusion was that high dietary calcium and phosphorus can indeppendently cause a conditioned zinc deficiency and that these effects are additive. (AH a3-12)

E. Management Practices and Equipment

1. Farrowing stalls. Ten different models of commercial farrowing stalls, including two "round" types and one adjustable from rectangular to "diamond" shape are under comparison. Satisfactory results in terms of prevention of mashing losses have been obtained with all models. A basic flaw in design was found in one rectangular stall with sides constructed of vertical bars spaced 7 inches apart. One of the first gilts confined to this crate got her head caught between the bars and required considerable help to get free. Horizontal bars, mesh or closer spacing of vertical bars, would prevent this type of mishap. Aside from safety and convenience of gate latches, bumper guards, etc., the main consideration appears to be cost per litter based on initial cost, maintenance, and durability of the unit. (AH a2-3)

2. Slotted floors for farrowing. Slotted floor units 10 feet by 7 feet were constructed of rough-sawed oak to accommodate two farrowing stalls per unit. Slots were 3/8 inch wide between slats which measured 2 1/8 inches

on top, 1 7/8 inch on the bottom, and 3 inches thick for the front and back of each unit, while three planks 12 inches wide made up the middle section. Pigs farrowed and reared to three weeks of age on these floors were noticeably cleaner than those reared on solid floors with bedding; moreover, no injuries to feet and legs of pigs occurred with 3/8 inch slots. (AH a2-3)

3. Feeding stalls for gilts and sows. In order to equalize feed intake in studies of optimum levels of nutrients required for gestating and lactating swine, individual feeding stalls have been installed and gilts reserved for the breeding herd are being fed at two levels during growth from 150 pounds until bred. Use of these stalls has prevented unequal feed intake and is providing a means for establishing optimum requirements of balanced diets for growth and gestation of gilts and sows. (AH a2-3)

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Nutritional Requirements

Stevenson, J. W. and Earle, I. P. 1964. Supplementation of sow lactation diets to prevent baby pig anemia. (Abstr.) J. Animal Sci. 23:299. (AH a3-12)

Stevenson, J. W. and Earle, I. P. 1964. Zinc in sows' colostrum and milk. (Abstr.) J. Animal Sci. 23:300. (AH a3-12)

PRODUCTION INFLUENCES ON SWINE
Animal Husbandry Research Division, ARS

Problem. Beef, lamb, pork, and poultry are excellent sources of wholesome and digestible animal proteins and fatty acids necessary in maintaining a healthy, appetizing diet. However, these meats must be of high quality, as well as in plentiful supply, if they are to retain their high position and esteem in the minds of consumers. Proper finish, a high proportion of lean, with adequate intramuscular fat, tenderness, full flavor, and color desired by the consumer are the goals the meat producer must strive to attain through breeding, feeding, and management. The quality of cuts and kind of meat are directly reflected in the demand and in the price of the product.

Egg shell strength and yolk quality, strength of wool, fatness, quantity, flavor, color, and tenderness of meat are all known to be influenced by production practices. However, these quality characteristics and many more are not well understood, even though they are of considerable economic importance. Effective measures of evaluating quality differences are of great importance in determining the nature and effect of production practices on the products.

USDA AND COOPERATIVE PROGRAM

This is a continuing program conducted by food product technologists, wool and fiber technologists, biochemists, chemists, physiologists, statisticians, and animal husbandmen engaged in both basic and applied research designed to develop methods and information which will be useful in evaluating quality and quantity of animal products and will be useful in aiding and directing livestock production. Research on beef, veal, lamb, and pork is directed at the influence of selection and breeding, nutrition, physiology, management, and other production variables on carcass and meat quality and quantity. Standards are being applied and adapted for appraisal of slaughter animals, of carcasses, and of meat cuts. The objective of the work with poultry and eggs is to ascertain those factors of nutrition, breeding, and management which contribute to the initial quality of poultry products and their capacity to retain that quality. Studies with wool, fur, and fiber are conducted to determine the physical, chemical, and biological structures and properties of wool and other animal fibers as influenced by production factors. Research on humane slaughter was continued on a reduced scale, primarily to bring to a conclusion some phases of electrical immobilization and physiological responses. The work is conducted at Beltsville, Maryland; Dubois, Idaho; Fort Wingate, New Mexico; and in cooperation with eight State experiment stations. Cooperation is also carried out with the Eastern and Western Utilization Research and Development Divisions, the Human Nutrition Research Division, the Agricultural Engineering Research Division, and the Market Quality Research Division.

The Federal scientific effort devoted to research in this area totals 15.6 professional man-years. Of this number 5.5 are devoted to beef; 1.1 to lamb, mutton, and chevon; 4.0 to pork; 1.0 to poultry and eggs; 2.1 to wool, fur, and fiber; 0.5 to humane slaughter; and 1.4 to program leadership.

A grant with the Polish Academy of Sciences in Poland provides for studies on the color of pork as influenced by heredity, sex, age, feeding, and management. Its duration is for five years (1960-1964) and involves PL 480 funds with $42,784 equivalent in Polish zlotys.

PROGRAM OF STATE EXPERIMENT STATIONS

Pork. A majority of projects discussed in the Nutrition and Management and Breeding problem areas include appraisal of the end product--the carcass. Research at some stations, however, has as its primary objective the influence of varying ratios of protein to energy and total feed consumption on carcass characteristics, and an evaluation of various criteria of selection for superior meat-type swine.

The total State scientific effort devoted to production influences on animal products research is 51.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

Pork

1. Tenderness and palatability. The degree of marbling in pork loins influences the overall taste panel desirability score of the heated loin roast. A study of loin roasts from 42 pigs of various ages suggests that loins with greater degrees of marbling are more palatable. Marbling scores of 1, 2, 3, and 5 (abundant) received palatability scores of 5.4, 5.6, 6.2, and 6.9, respectively. Among these same pork loins, those pigs that received full feed had palatability scores of 6.1, while loins of the other half of the pigs on a restricted energy ration had palatability scores of 5.1.

Among samples from 205 recurrent selection pigs, the tenderness of loin roasts was greater for the control breed-cross group than for the control line-cross (predominantly Landrace) group. The difference was noted in panel score, Warner-Bratzler shear value, and in tenderness press values. Loins from pigs with half breed-cross and half line-cross breeding averaged less tender than those from either of the parent lines. Although the number of F_1 animals tested was small, the 19 pork loins studied had average tenderness press values of 402 pounds; whereas the parent lines had average values of 317 and 357 pounds. These data suggest possible heterosis in pork tenderness.

Certain cross-sectional variations in tenderness were studied among 97 loin roasts by using a tenderness panel, Warner-Bratzler shear, and the slice tenderness evaluator (STE). The relatively small sampling area required by the STE allowed taking measurements at six locations within a slice of pork loin roast. STE shear values ranged from 4.07 pounds (tender) at a lateral location and 5.04 (slightly tender) at a medial location. Puncture values measured by the STE at a medial location were 40% higher than those at a lateral location. When data were grouped by general location area, the lateral portion of the loin slice was decidedly more tender than either the dorsal or medial portions. (AH a4-3)

A study of palatability and quantity of pork as influenced by breed and fatness indicated that differences due to breed and sex may be a factor to be considered in pork studies. In a study involving 119 Duroc and 111 Yorkshire pigs it was found that loin samples from Duroc pigs had significantly more intramuscular fat, more tender and juicier meat than similar samples from Yorkshire pigs. Barrows had a more desirable flavor of lean than gilts in the Duroc breed, with no difference in other quality factors. In case of the Yorkshires, the flavor of fat was more desirable in barrows than gilts with little difference in other quality factors. All of these pigs were fed to the same final feedlot weight of approximately 225 pounds and were fed the same ration. (AH a4-3)

2. Composition. The chemical analysis has been completed on 97 hogs slaughtered at 50-pound intervals from 75 to 275 pounds. An extensive least squares analysis has been completed on the analyses of ham lean, carcass lean, ham fat, and carcass fat. There were significant differences between weight groups in percentages of water, protein and ether extract fat for the ham and carcass lean. Gilts had significantly less ether extract fat in the ham lean than barrows. (AH a4-3)

Ultrasonic estimates of average subcutaneous fat thickness at four points were made on 66 pigs of various ages. The right side of each carcass was separated into lean, fat, bone, and skin. A closer relation was noted between the ultrasonic fat measurement and percentages of fat and bone than between the ultrasonic fat measurement and percentages of lean and skin. The effectiveness of ultrasonic fat measurements as an estimator of carcass percentage composition of fat, lean, skin, and bone is given by correlation coefficients of 0.85, -.67, -.70, and 0.83, respectively. These data show that as subcutaneous fat increases, percentages of lean and skin decrease, and percentage of fat and bone increase. (AH a4-3 and MQ 3-34)

3. Carcass evaluation. Studies were continued on ham volume as a method for determining yields of preferred cuts and composition. Volumes of total carcass, loin, and shoulder have also been constructed and are being statistically analyzed for possible use as an index of yield and composition of the live animal. (AH a4-3)

The influence of slaughter weight ranging from 100 to 200 pounds on desirability of cuts was studied with 80 carcasses from Yorkshires and crossbred barrows and gilts. Taste panel scores and cooking losses were not influenced to any marked degree by weight. Loin chops and 7-rib loin roasts from the heaviest pigs were preferred by consumers, while boston butt roasts from the lightest group were preferred. Customers would buy cuts from the lightest group, except 7-rib loin roasts, which were too small. As slaughter weight increased, the percent of primal and lean cuts decreased while carcass length, dressing percentage, and loin-eye area increased. Physical separation of the rough ham showed percent lean decreasing and percent fat increasing as weight increased. (AH a1-23)

Muscle development as related to age was studied in 32 pigs. Significant effects due to age were noted for area of muscle fiber, intramuscular fat deposition, iodine number of intramuscular fat, water content, and protein content. Growth curves of the expotential form based on estimate of the mature longissimus dorsi muscle indicated three periods of growth: (1) rapid growth from birth to 80 days, (2) transition from 80 to 120 days, and (3) fattening from 120 days to maturity. (AH a1-22)

4. Color. Research on color in pork as influenced by heredity, sex, age, feeding, and management was continued as a PL 480 study with the Institute of Animal Physiology and Nutrition Laboratory of Animal Products, Polish Academy of Science, Warsaw, Poland. The third progress report was divided into three parts -- influence of sample preparation; variation as influenced by husbandry factors (sex, age, etc.); and metabolic factors. Color in a cross-section slice of fresh muscle tissue varies to such an extent that it is difficult to subjectively or objectively evaluate it. A minced sample technique was developed, and the values obtained transformed into slice values which compare favorably with those values obtained directly from the slice. Variations in color due to husbandry practices was that of comparing the color of lean tissue as found in gilts and barrows. The results of this study show that meat of gilts is characterized in comparison with that of barrows by lower fat content, darker color, and greater concentration of myoglobin and total pigment. Water-holding capacity of meat did not differ significantly. As age and live weight of pigs changed moisture content of lean was lowered, fat content and protein content raised, water-holding capacity less, and myoglobin content increased. Though lightness of color was not changed, dominant wave length and saturation showed clear shifts. Stability of color changed as age and live weight increased. A study of the metabolic factors that may influence color is in progress, with no results to report. (E21-AH-2)

Humane Slaughter

1. Beltsville, Maryland. The study of physiological stress inflicted upon the hog previous to and during slaughter procedures was completed. The treatments consisted of captive-bolt stunning, electrical stunning, and no preslaughter stunning. The results showed small non-significant decreases in serum protein and in the albumin:globulin ratio when the hogs were immobilized with electricity. A highly significant increase in serum heme concentration occurred in the captive bolt and electrically immobilized groups. Evidence seemed to indicate that the symptoms of physiological stress might be the result of intense extensor muscular spasms associated with preslaughter stunning.

A similar study of the preslaughter and slaughter stresses due to captive-bolt, electrical, and no preslaughter stunning was conducted on lambs. Results showed that the serum heme pigment content was not increased significantly by the preslaughter stunning of sheep. Both the captive-bolt and electrical stunning methods produced a highly significant increase in plasma potassium values and there were small but non-significant decreases for total protein and albumin:globulin ratio in lambs immobilized previous to slaughter.

This project has been discontinued after a six-month extension. (AH j1-2)

2. University of Minnesota. Studies were continued on the complex problem of determining if an animal feels pain upon being immobilized by the use of electrical current. The results of this experiment are being evaluated. (AH j1-3)

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Pork

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Humane Slaughter

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Lynch, G. P., Fulmine, F. J., and Hiner, R. L. 1964. Some indications of physiological stress in lambs subjected to various preslaughter treatments. J. Anim. Sci., 23(3):661-664. (AH j1-2)

INFECTIOUS AND NON-INFECTIOUS DISEASES OF SWINE
Animal Disease and Parasite Research Division, ARS

Problem. Profitable swine production depends largely on the ability to control diseases. Swine diseases cause losses estimated at more than $200 million annually. In order to control and eventually eradicate these diseases, a thorough knowledge of causes, diagnostic procedures, preventive procedures, and treatments is required. Although a great deal of excellent research has been and is being accomplished, a vast amount of research is still required to obtain this knowledge. At present, the causes of several important swine diseases are unknown or incompletely understood. Extensive fundamental research on swine diseases is essential to the welfare of the swine industry.

USDA AND COOPERATIVE PROGRAM

The Department has a long history of swine disease research. For example, research on hog cholera was initiated in 1884. Research on this and other important swine diseases is a continuing long-term program. Modern research techniques in the areas of biochemistry, biophysics, pathology, microbiology, pharmacology, physiology, and immunology, are being applied to swine disease problems. Research is being conducted on the following diseases at the designated locations.

The Federal scientific effort devoted to research in this area totals 23.3 professional man years. This effort is divided among sub-headings as follows:

Hog Cholera 9.1 at the National Animal Disease Laboratory, Ames, Iowa, the Florida Hog Cholera Research Station, Live Oak, Florida, under a cooperative agreement with the University of Illinois, and under a contract with the University of Nebraska.

Atrophic Rhinitis 4.0 at the National Animal Disease Laboratory, Ames, Iowa.

Transmissible Gastroenteritis 3.6 at the National Animal Disease Laboratory, Ames, Iowa, and under cooperative agreements with Purdue University and the University of California.

Erysipelas 3.6 at the National Animal Disease Laboratory, Ames, Iowa, and in connection with a PL 480 grant to the Institute for Veterinary Research, Pulawy, Poland.

Brucellosis 3.0 at the National Animal Disease Laboratory, Ames, Iowa.

PROGRAM OF STATE EXPERIMENT STATIONS

Swine disease research at the State stations is being conducted on nearly all of the major disease entities of swine present in this country and on a number of other problems newly encountered or of growing importance.

Ten States are cooperating with the Department in a regional attack upon swine enteritis. These studies include identification and typing of bacteria found in outbreaks of this disease in an effort to trace the cause to specific bacterial types. The role which viruses play in causing intestinal disease outbreaks is under study - this includes joint efforts to develop diagnostic agents and immunologic procedures for transmissible gastroenteritis. Several States are using germ-free swine to determine the disease producing capabilities of single bacterial or viral species. Causes of disease outbreaks in Specific Pathogen Free swine herds are being studied to perfect this disease control procedure.

Other work is in progress to determine the causes of atrophic rhinitis and to develop practical means of prevention. More rapid and practical tests for diagnosing hog cholera are being developed and improved methods of immunization are being sought.

Increased emphasis is being placed on determining the cause and methods of preventing stomach ulcers in swine. Basic investigations are under way to evaluate the role of nutrition in swine disease and the mechanism of immunity in specific infections. The role of sensitization phenomena in causing the arthritic form of erysipelas is being studied.

The total State scientific effort devoted to swine disease research is 18.4 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Hog Cholera

Research at the National Animal Disease Laboratory, Ames, Iowa, was conducted in the following phases:

1. Antibody Reactions with Hog Cholera Virus. A soluble precipitating antigen (HCA) has been obtained from tissue cultured swine kidney cells infected with hog cholera virus. The antigen forms a single precipitin line in agar double diffusion with homologous antiserum. The specificity of the reaction was corroborated by the facts that hog cholera-immune sera did not react with control antigen, and nonimmune sera did not react with either the viral or control antigens. The antigen was readily separated from infective virus by DEAE-chromatography and by high-speed centrifugation. Following certain conditions of exposure to viable hog cholera virus, swine develop precipitating antibodies for HCA.

2. Heat Inactivation of Hog Cholera Virus. The hog cholera eradication program has made it necessary to obtain the answers to many unanswered questions. One of these questions is what temperature is required to kill the virus in pork and pork products. A total of 49 tests was made and 85 head of pigs were used to establish the effects on hog cholera virus blood, of heating at different temperatures for various lengths of time. Hog cholera virus in defibrinated blood was inactivated when heated at 69°C for 30 minutes, but was not inactivated when heated at 60, 62, 64, 66, and 68°C for 30 minutes. When the heating time was increased to 45 and 60 minutes, the virus was inactivated at 68 and 66°C, respectively.

When the preheating time was increased from 3 to 120 minutes and the heating time kept at 30 minutes, the virus was inactivated at 68°C. It was not inactivated at 66 C when the preheating time was increased to 140 minutes. Blood containing virus, when heated to 97 C, or boiling and then immediately cooled, was not inactivated. Virus in blood diluted to 80 percent with physiological saline (0.85 percent NaCl) was not inactivated at 68 C for 30 minutes. Virus in serum was attenuated when heated to 68 C for 30 minutes and inactivated when heated to boiling momentarily at 97°C.

3. A Study of Farm Swine Herds Vaccinated with Crystal Violet Glycerol Hog Cholera Vaccine. A five-year study was made of the same farm swine herds vaccinated each year to determine a) the ability of pigs vaccinated at the farm to withstand exposure to virulent hog cholera virus 1, 3, and 6 months after vaccination, b) the factors responsible for the inability of vaccinated pigs to withstand exposure to virulent hog cholera virus, c) the efficacy of a yearly vaccination with crystal violet glycerol vaccine in herds on the same farms for the prevention of naturally occurring hog cholera, and d) the efficacy of double vaccination of pigs that did not develop satisfactory immunity against exposure to virulent hog cholera virus after a single vaccination.

Crystal violet glycerol (CVG) vaccine was used to vaccinate 67,058 farm pigs from 1956 to 1960. Two test pigs from each herd were taken to the Federal Hog Cholera Res. Station at Live Oak, Fla., 1,3 and 6 months after vaccination and exposed to 1,000,000 MLD of virulent hog cholera (HC) virus under controlled conditions. A total of 2,931 pigs or 4.37 percent of all pigs vaccinated were exposed to HC virus. The percent survival for the 1, 3, and 6 month vaccinates was 86.33, 87.80, and 90.78, respectively.

Of 1,236 pigs tested 1 month after vaccination, 60.18% had good protection, 15.53% had fair protection, 10.51% had poor protection, and 13.67% had no protection.

Of 1,229 pigs tested 3 months after vaccination, 49.71% had good protection, 19.60% had fair protection, 18.22% had poor protection, and 12.20% had no protection.

Of 466 pigs tested 6 months after vaccination, 44.63% had good protection, 23.39% had fair protection, 22.74% had poor protection, and 9.22% had no protection.

The percent protection of the 1, 3, and 6 month vaccinates, based on their reaction to HC virus, was 71.91, 67.81, and 67.27, respectively.

Subclinical infection with Pasteurella spp. or Salmonella cholera suis is believed to have adversely affected the ability of pigs to withstand exposure to HC virus. An unknown agent responsible for a bloody diarrhea also interfered with the ability of pigs to withstand exposure to HC virus.

Hog cholera did not occur in any farm herd vaccinated with CVG vaccine. Hog cholera was known to have occurred, however, on many farms in the same area and on four farms adjacent to farms where CVG vaccinated pigs were being raised. Double vaccination with CVG vaccine induced over 95% protection in pigs in four herds where a single vaccination induced less than 30% protection. (Ames, Iowa - NADL) (ADP a2-17(c)

4. Pilot hog cholera eradication field studies to evaluate hog cholera vaccines. The evaluation of experimental field trial hog cholera eradication in Suwannee County, Florida, was begun in April, 1957, and was terminated December 31, 1962. The study was designed to measure the potency, safety, and shelf life of three types of commercial modified live-virus vaccines (lapine, porcine, and tissue culture origin), administered with a minimum of 15 ml. of anti-hog cholera serum. Records were kept on all vaccinated and unvaccinated swine herds.

A summary of the studies and final report, including conclusions, is as follows:

(1) Average annual swine vaccination coverage in the pilot hog cholera eradication area for the period was 73.1 percent. (2) Post-vaccination challenge of 4,842 pigs showed that 87.8% were adequately protected while 91.2% survived. (3) The farm-to-farm variation in the ability of pigs to develop an adequate immunity over the 69-month test period showed an average difference of 25.7 percent. (4) Twenty ml. or larger doses of anti-hog cholera hyperimmune serum, administered simultaneously with modified live-virus vaccines of all types, resulted in lower percentages of adequately protected pigs than smaller serum doses. (5) Stress factors recorded in 206 herds at time of vaccination had no significant effect on the development of immunity. (6) The most significant factor found to have an adverse effect on the percentage of adequately protected pigs was vaccine age at the time of vaccine administration. (7) Fifty-eight cases of hog cholera were confirmed during the period,of which 63.8% occurred in farm-raised swine. (8) More than one half of the feeder pigs (52.8%), delivered for sale to the public market, were not vaccinated.

After December 31, 1962, the field trial study was changed to measure the spreading characteristics of modified live-virus vaccines administered with and without hog cholera antiserum for the six basic patents or patents-pending covered by commercial production. In this program 945 pigs in 18 herds were vaccinated with 4 serials of modified live-virus vaccine manufactured under 2 patents with 10 ml. of antiserum per pig, and 530 pigs in 15 herds were vaccinated without serum. Non-vaccinated contact controls were left in each herd. Thirty days after vaccination, vaccinated pigs and an equal number of non-vaccinated contact control pigs were purchased for challenge. Six months after vaccination, or when the pigs were ready for market, whichever occurred first, another set of vaccinated pigs and non-vaccinated contact control pigs were purchased for challenge. At the present time 192 pigs from 49 herds have been challenged. The results of these challenges are incomplete.

Vaccination of swine with killed-virus vaccines was continued under the program for Lowndes County, Georgia, until March 10, 1964. Vaccinations are now being done privately, using killed vaccines. Challenge work of Lowndes County vaccinates continues to indicate two doses of killed-virus vaccines, 30 days apart, produce a higher level of immunity than 1 dose, even with the use of antiserum at the first vaccination. (Live Oak, Florida) (ADP a2-13)

5. Diagnosis of hog cholera. In research being carried out under a cooperative agreement at the University of Illinois, Urbana, cytopathogenic effects were observed in tissue cultures inoculated with hog cholera virus and incubated under increased oxygen tension. One difficulty in working with this virus heretofore was that it produced no visible effect in tissue cultures. This procedure holds promise as a diagnostic test for hog cholera. In other studies at the University, intradermal injection of attenuated hog cholera virus resulted in skin reactions in 15 percent of the swine that had been exposed to the virus 5 or more days previously.

Although the intradermal skin test appeared to be specific, the low reactor rate makes it of limited value as a diagnostic procedure. (Illinois)

In research conducted under contract at the University of Nebraska, Lincoln, a highly promising test for the diagnosis of hog cholera using a fluorescent antibody staining technique has been developed. The test is accomplished directly on fresh tissues such as tonsil, lymph nodes, salivary gland, and kidney. In experimental cases, hog cholera virus could be detected in the tonsil as early as 72 hours after exposure. (Nebraska) (ADP a2-17(C)

B. Atrophic Rhinitis

Research on atrophic rhinitis at the National Animal Disease Station, Ames, was temporarily suspended during the year. During this coming year efforts will be directed toward developing a swine herd free of turbinate anomalies and other diseases, to be used specifically on this project. (Ames, Iowa) (ADP a2-8(Rev.)

C. Transmissible Gastroenteritis (TGE)

In research studies at the National Animal Disease Laboratory, Ames, two isolates of virus from transmissible gastroenteritis of swine were adapted to grow on primary swine kidney cells. Purification and more characterization of the virus is now made possible. Previously, studies with this virus were limited to those findings which could be made in young specific-pathogen-free pigs which were relatively expensive and in limited supply. The tissue culture adapted viruses make possible a many-fold increase in the number of experiments that can now be accomplished. All previous attempts to grow transmissible gastroenteritis virus in tissue culture at this laboratory had been unsuccessful. Animal inoculation, virus interference, serum neutralization, and fluorescent antibody staining were techniques used to identify the isolates growing in the cell cultures. All confirmed the observation. (Ames, Iowa-NADL)

At the University of California, research is being conducted, through a cooperative agreement, on the enteroviruses of swine and their interrelationship. In California, a virus isolated from pigs with diarrhea was shown by neutralization tests to be serologically related to the Teschen group. The histologic changes observed in the central nervous system were indistinguishable from the polioencephalomyelitis noticed in pigs with Teschen disease. (Davis, California)

At Purdue University, Lafayette, Indiana, through a cooperative agreement, research is being directed toward elucidating the mechanisms by which transmissible gastroenteritis (TGE) virus causes diarrheal disease in young pigs and the means by which passive immunity to TGE is conferred from sows to their pigs. The site of replication of TGE virus in pigs is being determined by infecting surgically-isolated segments of the gastrointestinal

tract in anesthetized pigs. It appears that passive immunity to TGE is a result of neutralization of virus within the lumen of the alimentary tract by ingested antibody rather than by action of circulating antibody.
(Indiana) (ADP a2-10(Rev.)

D. Swine Erysipelas

There has been relatively little information pertaining to the underlying physiological changes in pigs during swine erysipelas infection. At the National Animal Disease Laboratory, Ames, Iowa, a study has been completed in which hematological, physiological and bacteriological parameters were measured in 13 pigs before and after infection with Erysipelothrix rhusiopathiae. Considerable effort was devoted to development of recording and sampling methods which minimized disturbance of the animals. Based on severity of clinical response, the animals were placed into three groups following infection: 1, acute with death; 2, acute without death; and 3, subacute. The most striking and consistent hematological change was leukocytosis followed by leukopenia. An initial shift to the left in the blood count was followed by an increase in lymphocytes and later by an increase in immature neutrophils. The cell sedimentation rates in groups 1 and 2 were significantly increased while blood pH values in these groups decreased. Groups 1 and 2 also had significant decreases in serum albumin and increases in a-globulin. The reduction in blood glucose paralleled the severity of infection. Blood creatinine was increased significantly in group 1, while blood urea nitrogen increased significantly in all groups. Serum glutamic oxalacetic transaminase increased 5-fold in groups 1 and 2. Blood pressures were consistently lower in all groups following infection, and dropped continuously until death in group 1. Heart rates of animals in groups 1 and 2 were first decreased, then increased, following infection. Maximum increases in body temperature occurred between 60 and 84 hours after infection. Erysipelothrix rhusiopathiae was recovered from all hemocultures from group 1, but was recovered less frequently from hemocultures from groups 2 and 3. The application of more recently available electronic instruments and techniques, coupled with concurrent biochemical and bacteriological tests during the course of erysipelas infection, furnished the means for this physiopathological study.

During the year a cooperative agreement was concluded with Seton Hall College of Medicine (Department of Biochemistry), Jersey City, New Jersey. During this study the organism which causes swine erysipelas, Erysipelothrix rhusiopathiae, was shown to possess five serologically active antigens when assayed by the agar double-diffusion technique. (New Jersey)

An investigation, carried out under a PL 480 grant to the Institute for Veterinary Research, Pulawy, Poland, is aimed at improving diagnostic and immunizing procedures for swine erysipelas. (E21-ADP-8) (ADP a2-15)

E. Swine Brucellosis

Work on swine brucellosis at the National Animal Disease Laboratory, Ames, was conducted on the serology, bacteriology, and histopathology of this disease. This research has not, as yet, progressed to the reporting stage.
(Ames, Iowa) (ADP a2-16)

F. Abscesses in Swine

Research on abscesses in swine was initiated at the National Animal Disease Laboratory, Ames, but has not progressed to the reporting stage.
(ADP a2-19)

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Hog Cholera

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Swine Erysipelas

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FOOT-AND-MOUTH AND OTHER EXOTIC DISEASES OF SWINE
Animal Disease and Parasite Research Division, ARS

Problem. Foreign diseases, such as foot-and-mouth disease, African swine fever, and Teschen disease, that occur elsewhere in the world, constitute calculable potential threats to the swine industry of the United States. Foot-and-mouth disease is of particular importance because the disease frequently occurs primarily in swine from which it spreads to other susceptible species, such as cattle and other ruminants. African swine fever, which until recently was confined to wild and domestic pigs in Africa, has spread to Portugal, Spain, and France. The disease is of special concern because of its resemblance to hog cholera, with which it may be confused. Moreover, mortality from the disease approaches 100 per cent, and there is no specific preventive vaccine. Teschen disease, which causes widespread inapparent infections and occasional involvement of the central nervous system, is another of the foreign diseases to be guarded against. A disease indistinguishable from Teschen disease has appeared in England in recent years. Despite all precautions, any of these diseases may occur in the United States, as likely as not through the medium of modern, rapid international transportation. The Plum Island Animal Disease Laboratory is engaged in studies of foreign diseases of swine for the purpose of developing information for increased protection of the Nation's swine industry.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving veterinarians, biochemists, microbiologists, and pathologists, engaged in basic and applied research in this problem area. Research is being conducted on the following diseases at the designated locations.

The Federal scientific effort devoted to research in this area totals 6.6 professional man years. This effort is divided among sub-headings as follows:

Foot-and-Mouth Disease of Swine 1.0 at the Plum Island Animal Disease Laboratory, Plum Island, New York.

African Swine Fever 4.6 at the Plum Island Animal Disease Laboratory in cooperation with the East African Veterinary Research Organization, Muguga, Kenya, and in connection with a PL 480 project in Madrid, Spain, where the equivalent of $97,550 has been made available to the Spanish Ministry of Agriculture over a 3-year period.

Rinderpest in pigs 1.0 at the Plum Island Animal Disease Laboratory, Plum Island, New York.

PROGRAM OF STATE EXPERIMENT STATIONS

Experimentation with the virus of foot-and-mouth disease in the United States essentially is prohibited by law except at the Plum Island Animal Disease Laboratory. Experimentations with the causative agents of other communicable foreign, or exotic diseases of swine in the United States is similarly prohibited generally by federal regulations. Consequently, the State Experiment Stations are not working with diseases in this category.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Foot-and-Mouth Disease of Swine

Foot-and-mouth disease in swine might well go unnoticed in those areas of the United States where vesicular stomatitis exists. Both viruses readily infect swine and clinically it is impossible to distinguish the infection. Foot-and-mouth disease virus, however, is more infective and generally causes a higher mortality than does the vesicular stomatitis virus. The problem is to conduct basic research to develop better means of diagnosing, control, and eradication of foot-and-mouth disease in swine. In those countries where foot-and-mouth disease exists, swine are the next most frequently affected animal, cattle being the principal species. Little is known concerning the infection in swine, nor is there a vaccine for use in this species. Vaccines used in cattle, while not perfect, do produce immunity after repeated vaccinations. This is not true in swine, thus vaccination is not widely practiced as a control measure against the disease in this species.

Studies have been commenced in swine using foot-and-mouth disease virus (FMDV), type C-3, CANEFA (designates a strain isolated from an outbreak in Argentina). Virus appears as early as 24 hours and persists for approximately 96 hours. Antibody was detected as early as 96 hours both by the variable serum-constant virus neutralization test in suckling mice and the Ouchterlony agar gel precipitin test. The early antibody as indicated by density gradient ultracentrifugation examination was of the 19S type. By the 7th day, both the 19S and 7S were present. The antibody level appeared to reach a peak by the 7th or 8th day. The virus modified by residence in primary bovine kidney cells for 182 days would appear to be insufficiently modified for other than experimental study. (ADP a9-1)

B. African Swine Fever

Until approximately 6 years ago, African swine fever (ASF) had never been known to occur outside Africa. Following introduction into Portugal in 1958, it spread to Spain. Efforts to eradicate the disease in these countries have not been successful. This is in spite of the use of attenuated vaccines. Early in 1964, the disease spread to southern France and by May had spread as far north as Brittany. Due to the incidence of hog cholera (European swine fever) in this part of France, difficulties are being

experienced in diagnosing ASF. While there is a laboratory test for diagnosis of ASF, difficulties are experienced in France in the use of the hemadsorption test for distinguishing ASF from hog cholera.

Basic and applied research is conducted by bacteriologists, chemists, and virologists at the Plum Island Animal Disease Laboratory, and at the East African Veterinary Research Organization. In East Africa, the research is being conducted under terms of a cooperative agreement with the East African Veterinary Research Organization, Muguga, Kenya, East Africa. Research is being conducted to develop information concerning the number and types of virus which may exist. In the approximately 8 years, during which USDA scientists have been working on the disease, 38 samples of virus have been collected and workers are in the process of comparing these to determine whether more than one immunologic type of virus exists.

During the past year samples of the virus responsible for three new outbreaks (Rhodesia, France, and a new area of Kenya) have been obtained. Of these specimens, 15 are from domestic pigs, 17 from wart hogs, 5 from bush pigs, and 1 from porcupine. During the past year, tissues from more than 300 hippopatomi have been examined and all have been shown to be free from ASF viruses. It was previously thought that this animal, along with the hyena, porcupine, bush pig, and wart hog, may be implicated in the spread of the disease. Following examination of the 300 specimens, it has been concluded that the hippopatomus does not play a role in the epizootiology of African Swine Fever.

Two strains of pig kidney cells and a strain of baby hamster kidney cells, have been found satisfactory for producing quantities of African Swine Fever virus. (ADP a9-2)

Under the terms of a PL 480 agreement, research is being conducted at the Servicio de Patologia, Patronata de Biologia Animal, Embajadores, Madrid, Spain, on rapid and accurate diagnostic methods for African Swine fever. USDA scientists, working on ASF in Africa, developed a laboratory test for the diagnosis of ASF. This is based on the adsorption of red cells onto cultures of buffy coat cells. Only those cells which are infected with ASF virus will adsorb red blood cells. The occurrence of ASF in Spain, and the need to conduct diagnosis on samples suspected of being ASF, provided an opportunity to study this method of diagnosis under actual conditions. The Spanish work has shown the test to be specific for ASF. They have published variously on their application of the hemadsorption test for diagnosis of ASF. For the most part, these publications have appeared in Spanish veterinary journals and in publication media of the Office of International Epizootics, Paris, France. (Spain) (E25-ADP-4)

C. Rinderpest in Pigs

A strain of rinderpest virus (Pendik isolate) which caused death in cattle was serially passaged 15 times in pigs. The clinical response of pigs included a rise in temperature and a reduction in white cell count which was statistically significant (P.01) at passage levels 0 (bovine origin virus), 5, 10, and 15. The virus did not increase in virulence for the pig as indicated by the absence of mortality. The virus retained its pathogenicity for cattle during the serial passage in swine. (ADP a9-3)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

African Swine Fever

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Rinderpest in Swine

Barber, T. L., and Heuschele, W. P. 1964. Experimental passage of rinderpest virus in North American pigs. Bull. Epiz. Dis. Africa. Oct.

PARASITES AND PARASITIC DISEASES OF SWINE
Animal Disease and Parasite Research Division, ARS

Problem. Parasitic diseases have been estimated to cost the swine industry of the United States at least $200 million annually. These diseases for the most part are cosmopolitan. Subclinical infections are the most frequent type and the most costly, yet they are generally so difficult to recognize that they often are overlooked entirely. Diagnosis is difficult, and successful treatments for many of these parasitisms are not available. Moreover, management practices to avoid the spread of parasitisms and to control them are often ineffectual. The problem is to develop, through a planned, balanced program of basic and applied research, knowledge for preventing, controlling, or eradicating parasitic diseases so as to provide for healthy swine, insure adequate supplies of parasite-free pork for an expanding population, avoid or minimize economic losses caused by these diseases, and thereby contribute to a prosperous agriculture, a sound national economy, a high standard of living, and a healthy population.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving parasitologists, veterinarians, biochemists, microbiologists, and pathologists engaged in basic and applied research in this problem area. Research is being conducted on the following diseases at the designated locations.

The Federal scientific effort devoted to research in this area totals 4.7 professional man-years. This effort is divided among sub-headings as follows:

The role of parasites in the economy of swine production 1.2 at the Beltsville Parasitological Laboratory, Beltsville, Maryland, and at the Division's laboratory at Tifton, Georgia, through informal cooperation with the Georgia Coastal Plain Experiment Station.

Bionomics and pathogenicity of the swine whipworm 0.5 at the Beltsville Parasitological Laboratory.

Swine kidney worms 2.1 at Tifton, Georgia, the Beltsville Parasitological Laboratory, and under cooperative agreement with the North Carolina Agricultural Experiment Station at Raleigh.

Investigations of Trichinella spiralis 0.5 at the Beltsville Parasitological Laboratory.

Effect of anthelmintic treatment on rate of gain 0.3 at Tifton, Georgia.

Pathogenic role of the intestinal roundworm 0.1 under a cooperative agreement with the Nebraska Agricultural Experiment Station at Lincoln.

PROGRAM OF STATE EXPERIMENT STATIONS

Six States have studies concerned with various phases of the internal parasite problem in swine. Part of this work is carried on under cooperative agreements with the Department. The major effort is centered on swine ascarids. Efforts are being made to develop methods of immunization or treatment which will prevent damage caused by migration of ascarid larvae through the body. Germ-free studies seek to establish the exact pathology caused by ascarids in the absence of other organisms. An evaluation is being made of the role which these parasites play in rendering swine susceptible to infectious diseases.

The migration patterns of kidney worms through swine are being traced and the resulting damage determined. Control and eradication procedures through management practices are being developed for this parasite. Anthelmintics are being evaluated for the control of Strongyloides infection in swine.

1.4 professional man years of scientific effort are devoted to swine parasite research at the States.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Swine kidneyworm

At the Animal Parasite Laboratory, Tifton, Georgia, a program for the eradication of kidneyworm, Stephanurus dentatus, from a naturally infested area was started on a private farm near Nashville, Georgia, in the fall of 1960. The management system consisted of breeding only gilts to farrow pigs and removing the gilts once their pigs had been weaned. From an infection of 93% of pigs farrowed by gilts from an infested area in the spring of 1961, the incidence of kidneyworms dropped to 50, 18, 6, and 0%, respectively, in succeeding semi-annual farrowings. All pigs farrowed by gilts raised either in the original kidneyworm-free area, or the original kidneyworm-infested area, were negative for kidneyworms in the spring of 1963.
(Tifton, Georgia)

At the North Carolina Agricultural Experiment Station, Raleigh, prenatal infection with kidneyworm was accomplished in each of 4 trials. This represented repeated doses of infective larvae during the length of pregnancy. It is felt that prenatal infection would be the reason why many young pigs in endemic areas show well developed parasites when they are slaughtered at 5-7 months of age. (Raleigh, North Carolina) (ADP b2-11(Rev.)

B. Intestinal threadworm

At the Animal Parasite Laboratory, Tifton, Georgia, infection of baby pigs with Strongyloides ransomi has previously been shown to be the most serious parasitic problem in swine of the South Georgia and North Florida area. Experiments have demonstrated prenatal infection of pigs with S. ransomi. This finding throws new light on the bionomics of the host-parasite relationship and may lead to new ways for control. Exposure of weaned pigs to infective larvae of S. ransomi established that 1 million larvae was usually sufficient to produce a marked reduction in the weight gains of infected pigs. (Tifton, Georgia) (ADP b2-17)

C. Intestinal roundworm

At the Animal Parasite Laboratory, Tifton, Georgia, observations have been made on the effects of anthelmintic treatment of pigs infected with Ascaris suum. Some of the trials were made with naturally infected pigs, others with experimentally infected pigs. Results of these experiments have been erratic and unpredictable. During fiscal year 1964, the research effort was directed toward making observations on the effects of adequate and inadequate rations on pigs infected with Ascaris. The adequate ration contained 16% protein and the inadequate 14 percent. It was found that the effect of migration of 125,000 Ascaris larvae was not as pronounced in reducing the daily gain of pigs as was the reduction in percentage of protein in the inadequate feed. (Tifton, Georgia) (ADP b2-4(Rev.)

At the Nebraska Agricultural Experiment Station, Lincoln, injection of serum, from pigs actively immunized by repeated administration of infective eggs, induced immunity in non-exposed pigs. This demonstrated that the immune factor circulates in the serum and can be extracted and used as an immunizing agent. Several new compounds were checked as ascaricides in a field trial. Piperazine was the only one that effectively killed worms. The others were either non-efficacious, non-stable, or were added at too low a level for action. The intraperitoneal implantation of a resin-coated organic phosphate checked the migratory stage of ascaris but tissue reaction precludes its application. It was found that migrating ascaris enhanced the severity of swine influenza; 90 per cent of mice infected with both agents died, whereas only 30 percent of those with only influenza died. The virus multiplied more rapidly in the doubly infected mice. Migrating ascaris caused severe liver lesions in swine. It was found that the liver completely recovers from this damage within 35 days. (Lincoln, Nebraska) (ADP b2-12(Rev.)

D. Swine whipworm

Continuing studies at the Beltsville Parasitological Laboratory, have shown that the eggs of Trichuris suis, the swine whipworm, have remained infective to susceptible pigs for approximately 8 years when exposed on the surface or when buried 4 or 8 inches in sandy loam soil. (ADP b2-10(Rev.)

E. Trichinellosis

Studies at the Beltsville Parasitological Laboratory showed that all trichinae in pork cuts weighing from 10 to 45 pounds were killed by a 20-day exposure in a 9 cubic-foot, chest type, home freezer, filled to capacity with 319 pounds of meat and set to operate at 0°F. Trichinae in 1-pound patties of ground pork were rapidly killed by exposure to 0°F in a home freezer. Exposure for 18 hours destroyed from 43 to 65 percent of the larvae. After 138 hours living trichinae were not found in the 1-pound patties, but 2 were found in a pail containing 13 pounds of ground trichinous meat.

Some evidence was obtained to indicate that the resistance of trichinae to the effects of freezing may be increased by prior exposure to 35°F for periods of 51 and 135 days.

Infection with trichinae occurred in non-trichinous pigs from the ingestion of feces of donor pigs containing larvae of this parasite passed within 4 days after the ingestion of trichinous meat.
(Beltsville, Maryland) (ADP b2-15)

Investigations on trichinellosis are also being conducted under a PL 480 grant to the Polish Academy of Science, Warsaw, on the epidemiological, epizootiological, and immunological aspects of this disease to establish information on the incidence of Trichinella spiralis in people and domestic and wild animals throughout the country. Allergic tests for diagnosis of the disease are being assessed. Other studies indicate that the intestinal flora in the host's digestive tract may affect the invasive ability of the larvae. (Poland) (E21-ADP-9)

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Swine kidneyworm

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Stewart, T. B., Hale, O. M., and Jones, D. J. 1964. Farm eradication of the swine kidneyworm (Stephanurus dentatus). Jour. Animal Sci., 23(1):302

Intestinal threadworm

ARS. 1964. Sows give parasites (Strongyloides ransomi) to unborn pigs. Agr. Res., 12(9):15, 16

Stewart, T. B., Smith, W. N., and Jones, D. J. 1963. Prenatal infection of pigs with the threadworm Strongyloides ransomi. J. Parasitology, 49(5,Sect. 2):45

EQUIPMENT AND BUILDINGS USED IN PRODUCING SWINE
Agricultural Engineering Research Division, ARS

Problem. Modern methods of producing livestock call for increasing use of engineering principles. More knowledge is needed about the effects of environment on animals and what str uctures and equipment are best suited to provide the most favorable environment. New and additional methods are needed for using electrical and other energy to replace costly human labor in many operations devoted to feeding and care of animals. Manure disposal, especially with confinement type operations near a metropolitan area, is becoming an increasing problem. To meet present day market demand for lean-type meat, producers need objective nondestructive methods and instruments for estimating the amount of lean meat in live animals.

USDA AND COOPERATIVE PROGRAM

This is a continuing program involving engineers and architects conducting basic laboratory investigations, application of laboratory results to a production basis, and development of typical plans for livestock structures. The work is in cooperation with the Animal Husbandry, Animal Disease and Parasite, and Entomology Research Divisions of ARS, USDA. Plan development work is cooperative with all the State Colleges through Regional Committees and with the Federal Extension Service, as part of the Cooperative Farm Building Plan Exchange. The professional man-years shown in parentheses at the end of each of the following sections may include work applicable to other species of animals.

A. Swine Engineering. Swine structures and equipment research is in cooperation with the California Agricultural Experiment Station at Davis and at the Imperial Valley Field Station, El Centro. Typical plans for swine structures are developed at Beltsville, Maryland. (1.5 PMY)

B. Water Supply and Wastes Disposal for the farmstead are studied at College Park, Maryland, in cooperation with the Maryland Agricultural Experiment Station. Liaison is maintained with the Public Health Service, the Water Systems Council, the American Society of Agricultural Engineers, and other organizations concerned with rural sanitation. (2.2 PMY)

C. Equipment and Control for Automatic Feeding of livestock and poultry is under development in Washington and Illinois State Experiment Stations. (2.9 PMY)

D. Environmental Research. Basic and applied studies on the use of heat pumps to modify thermal environment for hog production were recently started at Holland, Virginia, in cooperation with the Virginia Agricultural Experiment Station. (0.2 PMY)

E. Instrumentation. At Beltsville a program is underway to develop and provide accurate, practical and sometimes complex instrumentation for specific program needs. (1.7 PMY)

PROGRAM OF STATE EXPERIMENT STATIONS

There is an extensive program of both basic and applied research underway at the State Agricultural Experiment Stations in an effort to provide the answers to the continuing series of questions being raised by livestock producers. Demands are being made for more information on the effects of environment on the physical well being of all classes of livestock, and the way such optimum environments can be economically achieved; on new approaches to meet the growing labor shortage; on methods to adapt existing structures and equipment for greater economy of production; and on structures and related equipment for improved efficiency of feeding and materials handling operations.

Studies are being made of the effect of environment on the health, growth, production and fertility of dairy cattle, beef cattle, poultry and swine. Equipment and systems for efficiently transporting feedstuff into and out of storages and automatically mixing and feeding complete rations are being developed.

Exploring methods for improved care and housing of farm animals with greater economy and labor efficiency are also in progress as well as investigation of ways to modify existing structures and equipment to meet present-day economic conditions.

A widespread research effort is in progress which is attempting to investigate all of the factors involved in the complicated problems concerned with disposal of farm waste materials, particularly concentrated manures resulting from confinement-type livestock operations. The problem is most acute and the public is demanding a fast solution to this unsanitary and potentially dangerous health hazard.

Studies are conducted to obtain information on uses of electrical energy and explore new uses and test equipment. Many of the projects are concerned with the varied problems of chore labor mechanization and an expansion of the use of electricity for ventilating, heating, lighting, and cooling under the various production enterprises of today's farming operations. Development and testing of prototype specialized equipment for product collection, processing, packaging, and transport, as well as storage, loading and unloading devices, are a part of the overall program of investigations.

Approximately 45 professional man-years covering work on all animal species and poultry are devoted to these problems. Much of the research is conducted cooperatively with the Department.

USDA AND COOPERATIVE PROGRAM

A. Swine engineering

1. Effect of humidity on swine. Swine humidity-growth studies are being continued at Davis, California, in cooperation with the California Agricultural Experiment Station. Four pigs, weighing 20 pounds each were placed in each of three 20-square foot chambers in which the temperature-humidity-index (THI) and relative humidity (RH) were programmed in accordance with the following, up to market weight (200 pounds):

Weight, pound		50	100	150	200
Group I	THI	72	70	68	66
	RH, %	88	64	39	15
Group II	THI	66	68	70	72
	RH, %	15	39	64	88
Group III	THI	72	72	72	72
	RH, %	88	88	88	88

The results were:

	Group I	Group II	Group III
Average daily gains, lb.	1.43	1.34	1.35
LB feed/lb. gain	3.68	3.83	3.84

This test was repeated, using only three pigs per chamber, starting at 65 pounds and running to 212 pounds. The RH of each chamber was held constant throughout the test and the dry bulb temperatures were kept at the optimum values for the average weight of the pigs. The results were:

	Group I	Group II	Group III
RH,%	45	70	95
No. days	99	99	99
No. pigs	3	3	3
Total gain, lb.	140	146.7	154.3
LB feed/lb. gain	3.71	3.67	4.16

The differences in gain and feed conversion were not statistically significant.

2. Hot, arid, climate. At Davis, California, in cooperation with the California Agricultural Experiment Station, studies of sprinkler operation continued in a program to determine nozzle size and operational times to give the most efficient use of water for cooling pigs stressed by hot weather.

During the summer months, starting on June 24, 1963, a 78-day trial was run with five groups of ten pigs each, studying the comparative value of nozzles. The results were as follows:

	Control Group no spray	4.6 Nozzle 15:15 Min.on:Min.off [1/]	4.6 Nozzle Continuous Spray [1/]	6.4 Nozzle 15:15 Min.on:Min.off [1/]	6.4 Nozzle Continuous Spray [1/]
No. of pigs	9	10	10	10	9
Total gain, lbs.	113.8	122.9	117.0	122.0	110.8
Av. daily gain, lbs. per pig	1.46	1.58	1.50	1.56	1.42
Av. daily feed, lbs. per pig	6.86	6.64	6.16	6.87	5.97
Feed/unit gain, lbs.	4.89	4.22	4.10	4.39	4.29

1/ Gallons per minute at 100 lb. per sq. in. pressure

None of the differences between these groups was statistically significant.

At El Centro, California, the third in a series of three tests with air conditioning for pigs showed gains of 1.70 lb./day with feed and water inside the air-conditioned house, 1.65 lb./day with feed and water outside the air conditioned house, and 1.55 lb./day with a shaded wallow. Analyses of the three years' data indicate a significant increase in daily gain and daily dry matter consumption over the control group for those animals with the cooled house having feed and water inside. There were no significant differences between the gains of the groups in the cooled houses. The results are shown in the following table:

Comparisons of Air Conditioned Houses with a Shaded Wallow for Fattening Hogs (3 Years Data)

	Air Cooled House		Shaded Wallow
	Feed and water inside	Feed and water outside	
No. of animals	24	24	24
Initial wt., lb. [1/]	78	79	78
Total gain, lb. [1/]	133	130	124
Daily gain, lb. [1/]	1.73	1.69	1.61
Daily feed, lb. [1/]	5.71	5.43	5.27
Feed/100 lb. gain [1/]	330	320	327
Yield [1/]	69.0	67.0	67.3
Backfat, in. [2/]	1.90	1.80	1.75

1/ Average of Trials I, II, III (1961, 1962, 1963)
2/ Average of Trials I and II. Slaughter data from Trial III were lost due to inability to positively identify all animals after slaughter.

The necessity to recirculate the cooled air to maintain the low (70° F.) temperature in the cooled house uncovered a possible source of problems to be solved if air conditioning of animal shelters is practiced commercially. The floor of each house was relatively dry and the amount of dust collected on the return air filters was considerable. The average weight of dust collected was determined for weekly periods when the hogs weighed about 130 pounds and again as they approached 200 pounds. The two 20" x 20" filters (in series) on the house with the feed and water outside stopped a total of 20 grams/day and 40 grams/day at the weights indicated. When the feed and water were inside the house the amount of dust collected averaged 41 grams and 70 grams/day, respectively, at the two weights. Where the feed and water were outside, there was much more movement in and out by the pigs and consequently more dust causing materials being tracked in and being caught by the filters. The average composition of the collected material for each house is shown in the table. Two sets of filters for each house were necessary because almost daily changes were required to keep the heat exchanger from becoming plugged.

Composition of the Dust Collected on the Return Air Filters 1/

Source	Ash %	Silica %	Nitrogen %	Ether extract %	Crude fiber %	Lignin %
Cooled house (feed and water inside)	13.6	3.6	4.5	3.9	6.7	2.4
Cooled house (feed and water outside)	30.5	10.8	5.5	3.4	5.8	4.9

1/ Other constituents of dust not measured

3. Hot, humid climate. Studies on the value of shade and shade plus fogging for pigs and sows in hot, humid climates were continued at Tifton, Georgia. The same movable shades on skids and lots were again used in 1963. Forty pigs (average 53.5 pounds each) were held in small pasture lots (10 pigs per lot); two lots had shade plus fogging under the shade and two lots had shade only. An analysis of variance indicated a highly significant difference in rate of gain at the .01 level due to the fogging treatment. However, there was no significant difference in feed efficiency.

Sixteen bred sows and sixteen bred gilts were in temporary pasture lots (8 animals per lot); two lots had shade plus fogging under the shade and two lots had shade only. Average rectal temperatures and respirations per minute (on selected days) for the animals having access to the shade and fogging were 100.8° and 34.2, respectively, while the same measurements for the animals having shade only were 102.9° and 113.5, respectively. However, the average number of live pigs farrowed, birth weight of live pigs, number of pigs weaned and adjusted 56-day weight of pigs appeared to be equal for the two treatments. This is the second year's data and it is estimated that approximately four years' data will be required for analysis.

4. Level of feeding. At Escalon, California, studies on level of feeding of pigs were continued as an extension of a previously reported housing study. A cooperative experiment with a major producer involved the effect of limited feed intake on feed utilization. Three pens of 10 crossbred pigs each were placed on a daily feed intake of approximately 70 percent of NRC recommendations, three pens on approximately 80 percent, and three on approximately 90 percent, on April 15, 1963. The high level pigs were slaughtered July 23, the medium level on July 30 and the low level on August 13. These animals were slaughtered as they reached the same average weight of pig per feed level. The gains varied, as would be expected, according to the amount of feed. However, when the gains were adjusted by co-variance to equal feed consumption there were no significant differences, indicating that gross feed utilization did not differ between groups. There was a significant difference, however, in the specific gravities of the different groups and the specific gravities were inversely proportional to the level of feed consumption, as would be expected. Further analysis needs to be made to determine the utilization of energy.

5. Stand-up feeding. At Davis, California, in cooperation with the California Station, studies of stand-up feeding were continued with third and fourth replicates. The third extended from June 18 to September 30, 1963, with 2 pens of 11 pigs each (69 pounds average weight). One pen was control with a flat wood feed trough on the ground (12 feet long with 8-inch openings). The second had two 8-foot standup feeders. Aluminum shades were constructed to cover the feeders in each pen. There were no differences in total gain, average backfat thickness, specific gravity, weight of ham, percent of ham, weight of loin, or percent of loin. In cooperation with the Anatomy Department of the Veterinary School, some 18 individual muscles or muscle groups were dissected from the hind leg of one side of each hog carcass. These data have not been completely analyzed as yet. A fourth replicate was initiated on December 30 with the following treatments: control pen, 11 pigs eating from flat troughs on the ground; early standup, 10 pigs eating from standup feeders at start of test; late standup, 10 pigs eating from ground troughs to 130 pounds, then from standup troughs. The pigs weighed about 79 pounds at the start. Data from these tests have not been completely analyzed.

6. Slatted floors. Studies on the use of slat-feeding floors for swine are being conducted in cooperation with the Northeast Experiment Station, Duluth, Minnesota, to determine the material best suited for this type of floor; to determine the effect of this type structure on the labor requirements for caring for the animals and on animal health and feed efficiency. The first year's results indicate the wood slats are showing wear, particularly in the vicinity of the waterers. Present estimates are that they will have to be replaced after about three years of use. There is no evidence of wear on the steel or concrete slats. The slat-type floor was found to reduce the amount of labor required for manure removal. The saving amounted to 20 to 40 minutes per day per 100 hogs from that required for washing off the solid feeding floor. There was no apparent difference in animal health or feed efficiency. Visual observations during hot weather indicated a tendency for the animals to appear more comfortable on the slat floor.

7. Moisture loss. Studies on swine moisture loss were initiated at Davis, California, in the controlled-temperature laboratory, to try to develop a method of separating swine moisture loss into skin loss and respiratory loss. A restraining frame was designed inside a plexiglas tent (air tight) and a mask was designed to fit on the head. Total moisture loss is measured from the pig in the tent without the mask. With the mask on, skin moisture only is measured. Six crossbred pigs were trained to enter the tent and have the mask fitted over their heads. Tests are now in progress and the results look promising for developing workable techniques.

8. Plan development. No plans for swine structures were prepared during the year.

B. Farmstead manure disposal. Laboratory and field studies are continuing in Maryland, in cooperation with the Maryland Agricultural Experiment Station, on the characteristics of animal manures that affect their handling and disposal and on developing design criteria for disposal lagoons. Laboratory work has shown that a potable, sanitary "water" can be produced from manure lagoon effluent by chemical disinfection. The process should be within the means of many farmers. Observation of soil sealing and sludge buildup rates in an operating hog manure lagoon in Maryland substantiated previous laboratory findings of 39 days sealing time in a "Manor" soil and 1 mm. per month sludge buildup. Preliminary investigation of the effects of irradiation of lagoon liquids with radioisotopes indicated that it is apparently possible to sterilize the liquids with low-level radiation and that algae cells are rendered non-reproductive for varying periods.

The major portion of a manuscript for a publication on farm animal manure disposal was prepared.

C. Hog Feeding Equipment

In Illinois the field tests of an auger feed injector were continued. The injector operated for a total of 1,951 hours and showed no signs of significant wear. A new model has recently been placed on test for a continuing study of performance.

Grooves in the injector auger casing did not increase performance. The through-put and the maximum operating head were reduced when conveying ground feed.

There have been 3 licenses issued to manufacturers to produce the auger feed injector for sale as part of a pneumatic feed conveying system.

D. Equipment for Swine Environmental Studies

Studies on swine environment in cooperation with the Virginia Agricultural Experiment Station on buildings and equipment for efficient swine production, including the utilization of heat pumps, has been continued in the environment temperature controlled building. The facilities have been modified since previous report by installing identical steel slotted floors in half of the environment temperature controlled building and in half of the semi-open house.

Specific Pathogen Free animals are now being used in this work. Because of the time required for converting to these animals, no summer test was made. The winter test was conducted with two lots of hogs on the slotted floor and two lots on concrete floor of each house. The floor space of 8.5 square feet per animal was maintained for all lots. This test included 15 more animals than in previous tests and the load on the heat pumps was reduced. Temperatures were adequately maintained with limited operation of heating equipment. The effect of the increased cooling load from this number of animals in summer has not been determined. Data from all tests are being analyzed for the preparation of a progress report. The experiment will be continued to include both summer and winter tests.

E. Research Instrumentation

Ultrasonic reflectance measurements were continued on hogs, cattle, and sheep for correlation with yields of meat cuts. Longissimus dorsi thickness of cattle and sheep were statistically combined with liveweight and compared with area and weight measurements from cattle and sheep. The multiple correlation of ultrasonic measures and liveweight were: with cattle Longissimus dorsi area, 0.35; with cattle weight yield of round, rump, and loin, 0.95; with sheep weight of trimmed or untrimmed leg, 0.95. Yield predictions, based on liveweight, were improved by adding the ultrasonic measures. A recently available bio-medical pulse-echo instrument was trial used and compared with existing unit. Some advantages were observed in respect to convenience; however, the operation principle is basically the same as presently used equipment.

PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

Swine Engineering

Bond, T. E., Kelly, C. F., and Heitman, H., Jr. 1963. Effect of diurnal temperature on heat loss and well being of swine. ASAE Transactions 6:132-135.

Kelly, C. F., Bond, T. E., and Heitman, H., Jr. 1963. Direct air calorimetry for livestock. ASAE Transactions 6:126-128.

Kelly, C. F., Bond, T. E., and Garrett, W. N. 1964. Heat transfer from swine to a cold slab. ASAE Transactions 7:34-35.

Zeller, J. H., Bond, T. E., and Petersen, G. M. 1963. Hog lot equipment. Farmers' Bulletin No. 2192. July.

Wastes Disposal

Eby, Harry J. 1963. Manure disposal lagoons. ARS 42-75. June.

Hog Feeding Equipment

Puckett, H. B. 1963. Energy control in farm production. Agricultural Engineering. June. 44(6):320-322.

Puckett, H. B. 1964. Automatic feeding equipment for livestock and poultry. USDA Farmers' Bul. No. 2198. Mar. 28 pp.

Puckett, H. B., Klueter, H. H., and Olver, E. F. 1964. Medium pressure pneumatic feed conveyor. Illinois Research. Univ. of Ill. Agr. Exp. Sta. Winter. pp. 6-7.

II. NUTRITION AND CONSUMER USE RESEARCH

NUTRITION AND CONSUMER USE RESEARCH
Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help meet the Department's responsibility to advise consumers on the quantity and variety of foods that will assure maximum benefit and satisfaction, research must continue on the nutritional requirements of persons of all age groups, and on the nutrient and other values of foods and on how to conserve or enhance these values in household preparation and processing. Periodic surveys of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective programs of nutrition education. Information from such surveys provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and consumer use.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care, and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service -- the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done at Beltsville and Hyattsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas total 63.3 man-years. It is estimated that approximately 4.6 man-years is concerned with studies related to pork products.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 26.7 professional man-years and is described in detail in the report of the Human Nutrition Research Division.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Nutrient Value of Food

Food composition and nutritive value are most frequently related to indigenous agricultural products. Specific and locally grown raw products are being extensively evaluated for essential nutrients, especially in Hawaii and Puerto Rico. Much work is related to changes induced by growing practices, processing and storage.

The form of fats and lipids in food stuffs and the changes involved in processing and holding are receiving special attention as the role of different types of fat in human nutrition unfolds. Protein content and structure continue as active research areas.

Certain raw products are being evaluated for their significant vitamin contribution to nutrition. The effect of production and processing practices on vitamin content continues as an area of interest. Additionally, research has been directed toward the study of vitamins in food stuffs as affected by inhibitory and stimulatory factors.

The total program in this area includes 36 projects in 23 States and is comprised of 23.4 professional man-years.

Properties Related to Quality and Consumer Use of Food

In the area of food preparation, products are related to quality by some measure. Special measures characterize certain classes of products; i.e., vitamin assays, enzymatic activity, water binding capacity, and changes in structural tissues. Combinations of these are involved in the quality evaluation work reported.

The major research in product development is on the production, processing and storage of beef, pork, lamb, poultry and eggs. Variables which affect the initial product, include feeding regimens, age and breed, are under study. Conditions of processing relate to freezing temperature, storage temperature and time, shelf life, and the effect of light.

Other research includes the quality of meat tenderness as influenced by chronological age, post-mortem aging and in relation to connective tissue. Genetic factors which may be operative in establishing carcass characteristics is being investigated in sheep.

Food preparation research focusing on products for home use include: Heat penetration of meats and baked products and the chemical changes involved; microwave preparation of meats, fruits and vegetables, including the chemical alterations involved; and flavor characterization in frozen and stored products by means of vapor component identification.

Many of these same factors are under study in institutional preparation where the quantities involved impose special conditions.

This portion of the program includes 52 projects in 21 States and is comprised of approximately 50.1 professional man-years. This is a partial report of the State Experiment Station programs in food science and includes work undertaken by home economics departments. For research on food and fiber utilization see reports of the Utilization Research and Development Divisions.

Food Consumption and Diet Appraisal

The State program in food consumption and dietary appraisal extends the work of the Department to other segments of the population or to geographic areas not separately identified in the nationwide studies. Currently twelve States are contributing to this program. One regional project is designed to yield information regarding food purchase and consumption patterns of families with preschool children. This group represents about one-fourth of the households in the North Central Region where the study is being made. Food habits will be evaluated in terms of the children's dietary needs. This research will provide information useful to both consumer and market interests.

The State program in this area totals 22.2 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Nutrient Value of Food

1. Tables of food composition. Research for the newly revised Agriculture Handbook No. 8 "Composition of Foods...raw, processed, prepared" has been supplemented by further research during the year and adapted to the needs of special projects.

Formulas and procedures that were used in calculating the nutritive values of 250 food items commonly prepared at home are being summarized in a publication for special users, particularly therapeutic dietitians and medical research workers. A table showing average adjustments for vitamin losses during cooking has been developed and will be included in the publication.

Selected data from revised Handbook No. 8 have been made available in decks of punched cards and magnetic tape for research workers. Available in these forms are the data from Table 1, the nutritive values for 100 grams of edible portion of the foods; from Table 2, nutritive values for one pound of food as purchased; from Table 3, selected fatty acids in foods. Arrangements have been made for the sale of the cards and the tape by a private data processing firm in Washington.

Tables for the Department of Defense have been prepared on the composition of 630 food items procured by the Defense Supply Agency for feeding military personnel. Values for the composition of foods developed for Handbook No. 8 and many additional values provided by the Department of Defense were used to develop the data needed for the numerous special food products meeting military specifications.

2. Vitamins. Analyses for the vitamin B6 content and distribution in meats, including fresh and cured pork, and in vegetables available to and as eaten by consumers, are in progress. Analyses of cereal foods, fruits, nuts, and cheeses are nearly completed and manuscripts are in progress.

A fluorometric procedure for the determination of pyridoxine as pyridoxal cyanohydrin was developed. The reactions were quantitatively reproducible over a range in concentration of 1 millimicrogram to 1 microgram per milliliter. Procedures for chemical assay for pyridoxal and pyridoxamine previously had been developed in this laboratory. Present studies are to adapt chemical procedures to analyze food extracts for the three forms of vitamin B6. The procedures are expected to provide a more constantly reliable method for measuring this vitamin. Values from the chemical procedures are being compared with values obtained by microbiological determinations for vitamin B6 in foods.

Development of coordinated procedures for B-vitamin analyses continued with emphasis on a rapid, stable chemical method for nicotinic acid.

3. Proximate composition. Laboratory analyses were completed for proximate composition of lean and fatty tissues of raw and baked hams, pork loins, and other raw pork cuts. Statistical analysis of the data is in progress. Energy values are being calculated. The data will be integrated with data on mineral content of the same cuts.

Work is also in progress to modify existing methods for automatic nitrogen analyses to apply to all types of foods.

4. Lipids. Studies under contract with the University of Tennessee, on the changes in the fatty acid composition of fat in meats when cooked are estimated to be about half completed. These studies are on pork patties and ground beef using fatty acid composition of glyceride and phospholipid fractions as determined by gas-liquid chromatography, and infra-red spectra for indications of changes due to heating.

B. Properties Related to Quality and Consumer Use

1. Quality of fresh and cured pork roasts. Flavor, tenderness, and juiciness of fresh pork rib roasts as determined by a taste panel were not associated with original backfat thickness of the hog carcasses. Juiciness tended to increase with increase in marbling of the lean. Total cooking losses averaged 21 percent (6 percent as drippings and 15 percent as evaporation). This information was obtained under contract in Iowa and is based on evaluation of the right and left loins from 48 pork carcasses differing from 1.0 to 2.3 inches in backfat thickness.

Quick-cured hams containing different amounts of curing pickle were evaluated by a laboratory panel and by consumer panels in four cities. Four groups of cured hams, averaging 93, 100, 108, and 117 percent of the weights of fresh hams, were roasted at 325° F. to an internal temperature of 160° F. The laboratory panel rated the hams in the 108 and 117 percent groups more tender and juicy and better in flavor than hams in the 100 percent group. Comments that some hams in the 117 percent group were too juicy or too mild in flavor were made by some panel members. Preferences of the consumer panels were about equally divided among the four groups of quick-cured hams. Total cooking losses were slightly lower for hams in the 93 percent group and slightly higher for those in the 117 percent group than for hams in the 100 and 108 percent groups. A manuscript was accepted for publication in the Journal of Home Economics.

2. Freezer and refrigerator storage in households of pork sausage links. Flavor evaluations were completed for home freezer (0° F.) and refrigerator (45° F.) storage studies of pork sausage links made with and without the antioxidants BHA (butylated hydroxyanisole) and BHT (butylated hydroxy-toluene). Storage intervals representative of household practice were used. A report is in preparation. This work is cooperative with the Meat Inspection Division.

3. Freezer preservation of meat in the home. A publication on "Freezing Meat and Fish in the Home", was prepared in cooperation with the U. S. Department of Interior. It presents the latest recommendations on freezing techniques, storage time, thawing, and cooking. The bulletin points out that for high-quality frozen food it is necessary to have home freezing equipment that freezes food quickly at 0° F. or lower and maintains these temperatures for storage of frozen products. Too high or constantly changing storage

temperatures cause even frozen foods that are properly packaged to lose quality and food value. Illustrations show how to cut and bone pork, beef, and lamb and how to wrap these products for the freezer.

4. Measuring performance of fats in cakes. The effectiveness of physical measurements in indicating differences in consumer eating quality characteristics of white cakes was calculated from data obtained in the study of the performance of fats in preparation of cakes in households. Viscosity of cake batters and shear force measurements of cakes were good methods for assessing performance of fats as illustrated by high correlations with panel scores for tenderness, velvetiness, and evenness of grain of cakes. Volume of cake was also a good measure of performance of fats, whereas compressibility of cake was a rather poor one.

5. Food distribution program. Revision of the publication "Quantity Recipes for Type A School Lunches" (PA 631), was completed in cooperation with the Agricultural Marketing Service and the Fish and Wildlife Service, U. S. Department of Interior. This recipe card file provides 324 quantity recipes or variations and other information needed in preparing Type A lunches in schools participating in the National School Lunch Program. Recommendations on preparing, storing, and handling a wide variety of cereal, dairy, fruit, vegetable, meat, and poultry products were updated to take into account recent research findings and technology. New recipes were laboratory tested and taste panel evaluated, and all formulas and serving yields were recalculated in line with the 1964 revision of PA-270, Food Buying Guide for Type A School Lunches.

C. Food Consumption and Diet Appraisal

1. Planning for proposed nationwide survey, households and individuals. A nationwide survey of household food consumption and of the food intake of individuals is scheduled for 1965. Plans have been developed for a survey that would provide at least 6,000 household schedules and 10,000 individual schedules in the spring of the year with smaller household samples in each of the three succeeding seasons. The information on the week's food use to be obtained from each household is similar to that obtained in 1955, except that information on home baking practices will not be requested and information requested on home food production, home canning and home freezing will be reduced to allow interview time for questions on the food intake of individuals in the households.

In preparation for the proposed first nationwide survey of the food intake of individuals, data obtained by recall on the 1-day intake of food from nearly 550 individuals of all ages in Washington, D. C. during June and July 1963, have been studied in relation to two controversial issues that concern collection of data. The survey findings indicate that for this group: (1) the nonresponse rate on food intakes from individuals is not

influenced by taking a schedule on household food consumption first in comparison to taking none, nor is it influenced by taking a schedule on food intakes from half in comparison to all individuals in the family; and (2) homemakers report the amounts of food eaten by family members in terms of their individual servings far more often than as proportions of household amounts. Tabulations of the Washington data also are useful as a pretest for tabulation of the nationwide survey.

2. Effects of food distribution programs on diets of needy families. A survey of the food consumption of more than 800 households that were not participating in the food stamp program in St. Louis was made in May and June 1964 to determine the relation between usual family food expenditures and payments required for food coupons. Homemakers were asked also why their families did not participate in the program. Results of the analysis will guide the Department in revamping the St. Louis stamp program to make it more acceptable to eligible families and yet keep it within the limits of the program. Because of interest in the nutritional quality of food consumed by low-income families, an assessment may be made later of the dietary levels of these families. This is the sixth in a series of USDA food program surveys made in cooperation with the Marketing Research Division, ERS to assist the AMS to administer the food stamp and direct distribution programs.

3. Food consumption of the rural population in Spain (PL 480 research). A survey of the food consumption of the rural population in Spain has been initiated by the Spanish Ministry of Commerce under the cooperative sponsorship of the Economic Research Service and the Agricultural Research Service, using PL 480 funds. The study will provide information needed in appraising potential markets in Spain for U. S. farm products and should yield information useful to U. S. authorities on efficient ways of improving nutrition in low-income areas. The Spanish Ministry of Commerce expects to obtain much useful information on which to base a program for improving the diets of rural families, especially through better distribution of food. Information on food consumption, income levels, and related socio-economic characteristics has been obtained from about 1,200 rural families in 6 major regions of Spain. In summarizing the results, emphasis is being placed on (1) determining the nutritional shortages among these rural families at different income levels in the different regions, and (2) computing income elasticities for different foods as well as total food consumption.

4. Nutritive value of national food supply. The nutritive content of the per capita food supply is calculated each year from estimates of quantities of foods consumed (retail weight basis) as developed by the Economic Research Service. This series, which begins with the year 1909, is being completely revised to incorporate newest estimates of per capita consumption, revised food composition data from Agriculture Handbook No. 8, and new information on the nutrients added to foods by enrichment and fortification.

A survey conducted by the Bureau of the Census for the Consumer and Food Economics Research Division has provided information for the years 1957-61, on quantities of enrichment ingredients supplied to processors to fortify flour and cereal products. Through this program about one-third more thiamine, one-fifth more iron and niacin and one-tenth more riboflavin are added to the Nation's diet than would be available if foods were not enriched.

For the first time, the enrichment survey was extended to include information on the quantities of ascorbic acid and vitamins A and D added to foods, thus furnishing a base line for future surveys. Currently the amount of ascorbic acid added to foods would be enough to increase the level in the per capita food supply by 5 percent. The contribution from synthetic vitamin A is 7 percent of which 6 percent is added through margarine. Vitamin D is not at present included in nutrient estimates.

5. Household practices in home freezer management. Recording forms and questionnaires for obtaining data on management practices of urban and rural home freezer owners were pretested and necessary revisions were made in preparation for data collection among households in Fort Wayne and a nearby rural area. Information will be obtained in two seasons on the kinds, amounts, sources, prices, and turnover rates of frozen foods stored in the home. Such data will provide information needed to develop guidance materials for improved management of home freezers.

6. Development of food budgets and other basic data for food and nutrition programs. Interpretation of nutrition research findings and their application to practical problems has continued as part of an ongoing program to assist nutritionists, teachers, health workers, and other leaders concerned with applied nutrition programs or nutrition policies. Information developed under this program is provided to many groups both within and outside the Department working on practical food programs, on questions relating to nutritional requirements, food consumption, nutritional importance of specified foods, and on nutrition education. Increased emphasis has been given this year to opportunities for disseminating information to the public through TV and radio, the press, conferences, workshops, and the Department's Food and Home Fair.

Food budgets at different cost levels for individuals and families are priced quarterly for publication in Family Economics Review as a continuing service to welfare workers, extension agents, and others needing this information. For example, in June 1964, the cost of one week's food for a family of four including 2 school-aged children, was estimated to be $24.40, $32.80, and $37.40, respectively, for the low-cost, moderate-cost, and liberal plans.

The food budgets published in Home Economics Research Report 20, "Family Food Plans and Food Costs," have been reexamined in the light of revisions in food composition data (Handbook 8, revised) and in recommended dietary allowances of the National Research Council. Some modification in food quantities was needed for certain individuals. This has necessitated revision of food plans and their presentation in technical and popular publications, including Agriculture Handbook 16, "Planning Food for Institutions," now being readied for publication. The "Food Purchasing Guide for Group Feeding," formerly a part of Agriculture Handbook 16, is in the final stages of editing for publication as a separate handbook.

All other existing guidance materials for nutrition programs were reviewed in light of the changes in recommended dietary allowances and in food composition data. Some publications have been revised; others will be updated for the next reprinting.

Nutrition Program News, a bimonthly periodical prepared for members of State nutrition committees and other community nutrition workers provides one channel for disseminating pertinent information about Federal programs and for reporting nutrition activities in the States. Issues this year included such diverse subjects as a report of the World Food Congress held in Washington, June 1963, "Labels on food products--the protection they give," and "Nutritional fitness for teenagers." Assistance to workers in nutrition programs has been provided also through consultation and program participation by staff nutritionists.

PUBLICATIONS--USDA AND COOPERATIVE RESEARCH

Nutrient Value of Food

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Properties Related to Quality and Consumer Use

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Food Consumption and Diet Appraisal

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III. MARKETING AND ECONOMIC RESEARCH

MARKET QUALITY OF PORK

Market Quality Research Division, ARS

Problem.

Meat is a very perishable commodity which varies greatly in quality characteristics such as tenderness, juiciness, flavor and fat content. To the consumer the visual characteristics of meat quality are primarily color and fat-to-lean ratio. However, properties such as tenderness, juiciness and flavor cannot be judged so simply. The meat grader attempts to evaluate these quality factors by relating quality to evidences of maturity, texture of the lean, and degree of marbling. To insure more uniform grades and standardized products, better objective tests for measuring the quality attributes of tenderness, juiciness and flavor in meat are needed. Also needed are more effective methods for maintaining optimum quality by minimizing such deleterious effect as shrinkage and bloom and by enhancing the shelf-life of meat as it moves through market channels.

USDA PROGRAM

This work is being conducted at Beltsville, Maryland, with the cooperation of the Animal Husbandry Research Division, ARS, the Livestock Division, AMS, and in part by research contract with the University of Missouri and by cooperation with the University of Illinois. Research programs concerned with the development of new techniques for measuring meat tenderness and for evaluating the composition of livestock, carcasses and meat cuts are underway. The application of the ultrasonic technique to estimate the thickness of backfat and muscling in live hogs, cattle, and sheep is one example of this type of research. Another area of interest is concerned with the use of improved sanitary practices in the merchandising of meat to extend shelf-life and to develop objective methods for the evaluation of quality and shelf-life of prepackaged fresh meats. Studies are also underway to standardize lighting conditions in work areas where meat grading is done.

To augment in-house research at Beltsville a new meat laboratory has been established. Here instrumental techniques in conjunction with classical methods of organic and biochemistry are applied to problems concerned with the evaluation and maintenance of meat quality. Basic information gained at the molecular level concerning proteins, electrolytes, phospholipids,

triglycerides and other meat constituents will be used in attempts to establish objective methods for quality evaluation.

A grant with Robert College, Istanbul, Turkey, provides for the development of an odor-measuring instrument for use in inspection and grading of foods. Its duration is for 5 years, 1961-1966, and involves P.L. 480 funds with a $29,361 equivalent in Turkish liras.

A grant with the Research Center of the Meat Industry, Helsinki, Finland, provides for a study on the effects of carbon dioxide or nitrogen on refrigerated meat. Its duration is 4 years, 1963-1967, and involves P.L.480 funds with a $44,453.40 equivalent in Finnmarks.

The USDA scientific effort devoted to research in this area totals four professional man-years of which one man-year is on contract and 2.5 man-years are in the area of objective measurement and evaluation of quality.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Research directed to increasing our understanding of the market quality of meat has been a continuing part of the state stations' research program. Both basic and applied research are involved.

Market quality research on meats begins with study of the influence of breeding, feeding and management treatments with cattle, sheep and swine on the carcass and meat quality characteristics. The objective is to determine the relationships of live animal and management factors to ultimate eating quality. Such live animal traits as birth weight, rate of gain, efficiency of gain by sire groups, body measurements such as depth and length of body, type, market weight and grade are related to carcass traits such as loin eye area, muscling characteristics, amount and distribution of fat, yield of wholesale cuts, chemical composition and carcass value in an effort to define animal traits which influence carcass and meat quality.

Other research involves investigation of various pre-slaughter treatments on the carcass quality, organoleptic characteristics and market value of the meat. Special attention is given to tenderness of meats and the fundamental causes of toughness or tenderness in meats. Certain post-mortem factors including aging exert profound effects on meat quality and considerable effort is devoted to attempts to gain a better understanding of their effects.

Almost all of the studies involve a certain amount of work on methods since methodology is of vital importance in the study of quality factors. Development of objective criteria for evaluation of meat quality is a continuing

goal and new and improved methods of defining the quality of meat cuts are constantly sought.

Further along the route to the consumer, concern arises as to the effects of processing and storage treatments on the quality of meat. The influence of maturity, marbling, methods of aging and processing and storage, packaging and distribution are all studied for possible effects on ultimate quality. Microbial quality, distribution of muscle proteins and lipids, morphological features, amount of connective tissue, and cooking treatment are other factors considered in attempting to establish the total quality characteristics of meat. Finally, the relationships of raw and cooked meat quality to consumer preference are determined. These are in turn related to the carcass quality and market value of the live animal.

A total of approximately 17.7 professional man-years are devoted to market quality research on meats.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Objective measurement and evaluation of quality

1. Yield of Lean Meat from Cattle of Different Conformation. The study in cooperation with the Livestock Division and the University of Illinois comparing two groups of cattle of different conformation but of the same USDA Quality Grade (Choice) has been completed. Results showed that there were no differences between the yield of lean meat from these two groups of beef carcasses when evaluated according to the system of determining yield developed by USDA. Palatability studies comparing these two groups of carcasses showed no difference in eating quality as judged by a six-member taste panel or by Warner-Bratzler shear determinations. Analysis of the beef carcass data in order to develop correlations and multiple regression equations that can provide guidelines to measurements that account for the greatest amount of variation in yield of lean meat from these wholesale cuts have also been completed.

(MQ 3-34)

2. Measurement of Tenderness. In a study being conducted cooperatively with Animal Husbandry Division the tenderness of cooked loin steaks and rib roasts of beef, representing a range in carcass grade from Utility to Choice are being measured. Subjective tenderness evaluation data are being obtained by taste-panel judgements; objective measurements by Warner-Bratzler shear determinations and measurement on puncture and shear using the Slice-Tenderness Evaluator (STE) developed by USDA. This phase has not reached the stage for reporting findings.

(MQ 3-34)

3. Relationship of Marbling to the Palatability of Beef. This project has been initiated to study the relationships between marbling and composition, concentration and distribution of lipid material in beef muscle. Marbling plus this type of knowledge, or this information alone, may provide a more object method for the evaluation of palatability than marbling per se. This project is in its initial stages and no findings can be reported.
(MQ 3-60)

4. Flavor Studies to Provide a Basis for More Objective Measurements of Meat Palatability. This project has been initiated to develop objective procedures for identifying and evaluating flavor characteristics of meat by studying the compounds and precursor systems responsible for meat flavor. Studies on beef and lamb are underway. A fraction has been isolated from unheated lamb fat that possesses characteristic lamb aroma. This crude fraction has been partially separated and procedures for the quantitative collection of these sub-fractions developed.
(MQ 3-61)

5. Objective Methods for Measuring Maturity. Stages of physiological maturity should be reflected in differences that can be measured at the molecular level in muscle tissue. A comparative study of the proteolytic activity of tissue, from similar muscles, from animals of different chronological age has been initiated in order to see if this measure of enzymatic activity can be correlated with maturity. New analytical procedures are being now developed in order to carry out the objectives of the research project. (MQ 3-62)

6. Odor-Measuring Instrument. This project covers research being undertaken in Turkey under P. L. 480 funds. The investigator came to the United States and discussed the development and research basis for his instrument at a scientific meeting held in Washington on odor measurement.
(A22-AMS-1(a))

B. Quality maintenance in handling and packaging

1. Shelf-life of Prepackaged Meats. The University of Missouri has completed several storage cycles for beef and pork, under the contract, to study the factors affecting the shelf-life of prepackaged meats. Each cycle included different sanitation levels under controlled cutting room temperatures. As a result of this work a revised manual containing new recommendations for temperature, humidity, sanitation and handling procedures for fresh meats is being prepared.
(MQ 2-75)

C. Quality maintenance during transportation

1. Effect of Atmospheres of Carbon Dioxide and Nitrogen on Properties of Refrigerated Meat. The first annual report (covering period April 1, 1963 - March 31, 1964) was received under this P. L. 480 research grant. During the report period only one test series with meat kept in normal atmosphere was carried out. The greater part of the report period was consumed in procuring equipment and in trial runs and in developing the chemical and bacteriological methods of analysis.

(E8-AMS-5(a))

PUBLICATIONS REPORTING RESULTS OF USDA AND COOPERATIVE RESEARCH

Objective Measurement and Evaluation of Quality

Carpenter, Z. L., R. G. Kauffman, R. W. Bray, and K. G. Weckel. 1963. Factors influencing quality in pork. B. Commercially cured bacon. Jour. of Food Science 28(5):578-583. (MQ 3-9(c))

Feinstein, Louis and Richard L. Hiner. 1963. Anesthesia and its relationship to body composition. Annals of the New York Academy of Sciences 110:1141-1145. (MQ 3-34)

Hornstein, I. and P. F. Crowe. 1964. Meat flavor - a review. Jour. of Gas Chromatography 2(4):128-132. (MQ 3-61)

LIVESTOCK AND MEAT - MARKETING FACILITIES, EQUIPMENT AND METHODS [1/]

Transportation and Facilities Research Division, ARS

Problem: Many of the livestock and meat slaughter and warehouse facilities occupied today are obsolete and the work methods that can be used in such facilities are antiquated. As a consequence, labor costs are excessive and they are increasing. Many firms still are occupying facilities designed primarily for handling rail receipts and rail shipments even though the majority of these products today are moved by motortruck. This situation also adds to handling costs. Numerous firms are occupying "makeshift" facilities which were designed for other uses or for work methods and operations of a bygone era when labor costs were low. Changes in transportation systems, population growths and shifts, and advancements in technology also have brought about changes in the types of facilities -- such as livestock auction markets, commercial feedlots, and hotel supply houses. Most private firms handling livestock and meat develop suitable facility layouts and designs snd to select the types of equipment needed. Therefore, engineering and related research is needed to provide guidelines for industry to increase efficiency including the designing of improved plant layouts which will provide proper arrangement of work areas to minimize travel distances and excessive handling and the development of work methods that will permit use of mechanized and automated equipment rather than the relatively high-cost manual methods now used in many plants.

1/ The work described here is part of an overall program aimed at improving market facilities and market operations. As agricultural commodities flow through marketing channels they converge with similar products, for example, meat, poultry, fish and dairy products are often handled by the same wholesaler and reach consumers through the meat and produce department of retail stores. Because of this situation, improvements in the overall marketing process can bring about benefits that affect several commodities simultaneously. The component costs of marketing have been rising rapidly and would have risen more if the results of this type of research had not been available. In the marketing of food commodities in 1963, at least $30 billion (75% of the total food marketing bill) were expended on marketing operations that are directly affected by the research covered in the overall program. The overall program includes (1) terminal wholesale marketing planning, (2) preliminary and followup work in terminal market areas, and (3) production area and independent marketing facilities such as that described here. Terminal wholesale market planning was conducted in 7 major cities last year. Production area and independent market facilities planning involved 41 studies. For additional information see "A Summary of Current Program and Preliminary Report of Progress" dated September 30, 1964, by the Transportation and Facilities Research Division, ARS, USDA.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program devoted to planning marketing facilities in which application is made of engineering, economic, and marketing principles. This work is concerned with structures, equipment, containers, devices, work methods, and operating methods used in marketing and transporting farm and food products from farms to consumers. The functions to which these physical elements, handling methods, and labor relate include essentially all marketing operations, especially those directly applicable to the commodities in the physical sense such as assembling, preparing for market, processing, packaging, precooling, loading, transporting, unloading, storing, warehousing, and wholesale and retail distribution. The part of the program pertaining to swine involves industrial engineers, agricultural economists, and meat scientists engaged in both basic and applied research to develop new and improved methods, equipment, processes, and facilities for livestock markets, meatpackers and wholesalers. Livestock market research is carried on at Hyattsville, Md. Part of the work in this area is being done in cooperation with the Missouri Agricultural Experiment Station, Columbia, Mo., and the Central Missouri Livestock Auction, Mexico, Mo. Work on the development of a mechanical driving device and penning system for livestock markets is under a contract with the American Research and Manufacturing Corporation, Rockville, Md. The research on livestock slaughtering and on meatpacking and wholesaling at Stillwater, Okla., is cooperative with the Oklahoma Agricultural Experiment Station.

The Federal effort devoted to research in this area during the fiscal year 1964 totaled 5.1 professional man-years: 2.1 man-years (including 1.8 man-years of contract work) on livestock marketing, 2.3 man-years on meat facilities, and 0.7 man-year on program leadership.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

A. Automation of Sales Operations on Livestock Markets

At the Central Missouri Livestock Auction, Mexico, Mo., the combination electronic load-cell and lever-system scale, and the scoreboard for flashing total weight, average weight, and price to the audience continues to perform well. The manual-key input device for transmitting sales data from the auctioneer's box to the office and the computer for processing this information could not operate at the speed of the fastest sales transaction. During the year the Toledo Scale Corporation, which provided this equipment, abrogated the Memorandum of Understanding covering this part of the work.

The contractor's report from the Toledo Scale Corporation on the physical and economic feasibility of electrically-operated gates was favorable and provided information on gate structure, latching designs, drive systems, and remote controls. A cooperative agreement was negotiated with the Missouri Agricultural Experiment Station for constructing and testing of prototype electrically-operated pen gates. Working drawings, based on data in the contractor's report, were provided the cooperator. Construction of the prototype gates was underway at the end of the report year and laboratory tests and modifications will continue for several months. Tests of the gates under actual operating conditions will be conducted on the Central Missouri Livestock Auction, Mexico, Mo.

B. Determining Behavioral Patterns of Livestock

Under a contract with the American Research and Manufacturing Corporation, Rockville, Md., research to establish behavioral patterns of cattle, hogs, and sheep under environmental conditions existing on stockyards and auction markets was conducted on a site leased from the Baltimore Union Stockyards, Baltimore, Md. The research involved determining the reaction of each species of livestock to (1) light rays of different candlepower, intensity, and bands of the spectrum, (2) sound of different pitch and intensity, (3) air blasts of different velocities and temperatures, (4) electricity applied at different voltages and by various means, (5) a moving "sweep" or "driver" of alley width equipped with selected devices, including rubber fingers, for prodding animals, and (6) selected combinations of the media listed above. The purpose of this research was to determine the feasibility of driving and penning livestock automatically.

The results of the experiments showed that a mechanical sweep with electrically charged bars was the most feasible device or stimuli for driving and penning livestock. No favorable reaction was obtained from the experiments with light rays. These included mercury vapor lamps, flashing xenon lamps, colored lights (red, blue, green, and yellow), and infrared-heat lamps. Reaction to the experiments with sound ranged from moderate to good. White noise produced the least favorable reaction, sinusoidal sound was better, and the amplified human voice was the best of the sound stimuli. Sound was eliminated from consideration as a possible driving device because of the possible effects on other livestock in the market other than those being driven and its irritation and possible painful effect to humans in the market area. Air blasts were considered a relatively good driving stimulus but were less effective than the mechanical sweep with electrically charged bars. The results of the experiments with the mechanical sweep with electrically charged bars were considered sufficiently favorable to proceed with construction and testing of a prototype driving device.

C. Developing an Automatic Driving and Penning System for Livestock Markets

A contract was negotiated with the American Research and Manufacturing Corporation, Rockville, Md., to design, construct, and test a mechanical driving and penning device for livestock markets based on the results of the research on animal behavioral patterns. At the end of the report year the contractor had submitted design drawings of the device in accordance with the requirements of the contract and was proceeding with construction of the prototype.

D. Developing a Physically Integrated Livestock Marketing and Slaughtering Facility

Due to lack of personnel, no work has been done on this project. Research in this area would draw heavily on the results of previously completed livestock marketing and slaughtering work and would require personnel who had either participated in this work or had gained from other sources a broad and comprehensive working knowledge of the engineering and technical skills needed to carry on this work. Personnel qualified to work on this project have been lost due to transfer or reassignment and it has not been possible to employ suitable replacement personnel to do the work. In view of these circumstances, the project has been discontinued until such time as qualified personnel are available to carry out the work.

E. Layouts and Work Methods for Hotel Supply Houses

At Stillwater, Okla., a draft of a report entitled "Hotel and Restaurant Meat Purveyors--Custom Service Houses--Improved Methods and Facilities" was revised to include suggestions made by industry representatives to make the report of more value to and more easily understood by the operators of hotel supply houses. At the end of the year, the report was in Branch clearance.

A draft of a second manuscript covering frozen portion control hotel supply houses was almost complete at the end of the year. This report covers receiving and storing fresh and frozen primal and boneless cuts of meat, fabricating and packaging steaks and chops, preparing ground meat and forming meat patties, freezing packaged products, casing and storing frozen products, and loading out cased products. The report compares the relative efficiency of the various work methods, and equipment types used in performing inplant operations. Use of the lowest cost methods in a plant handling an average of 75,000 pounds of meat and meat products weekly would reduce labor and equipment costs about $15,500 or 17 percent. Most of the savings are in the labor costs and are due to the use of mechanized equipment such as conveyors, dump-buckets, patty machine feeders, and forklift trucks. An efficient layout was developed based on the lowest cost methods and equipment for this size plant.

F. Layouts and Work Methods for Hog Slaughtering Plants

At Stillwater, Okla., in cooperation with the Oklahoma Agricultural Experiment Station, field studies were completed in hog slaughtering plants in 10 central and southern States. The research covered plants slaughtering from 75 to 125 hogs per hour. Most of the plants studied were operating at about 3 to 3.5 hogs per man-hour, substantially less than the goal of 5 hogs per man-hour for small to medium size hog slaughtering plants. The relatively low slaughtering rate found in most plants was due to innefficiencies in the following operations: Driving, stunning, shackling and bleeding, and scalding and shaving. Proper control of scalding temperatures and maintenance of the dehairing machine are the items that would do most to improve efficiency of the slaughtering line. Layouts showing the arrangement of equipment and work areas for an efficient flow of carcasses through the plant have been prepared. A draft of a manuscript covering the results of this research is underway.

G. Handling and Processing "Hot" Pork Products

At Stillwater, Okla., a cooperative project with the Oklahoma Agricultural Experiment Station to study the feasibility of fabricating, curing, smoking, boning, and chilling pork cuts from the "hot" carcass continues. The first 20 pork carcasses were processed and the data obtained were analyzed. The analysis shows that:

1. Yield data are about the same for "hot" and "cold" processed sides.

2. There are no significant differences in flavor, juiciness or tenderness between the hot and cold processed sides.

3. Cutting and boning of the hot side is easier and faster than for the cold side. The information obtained from the first 20 pigs slaughtered is very encouraging.

The second group consisting of 40 pigs were slaughtered in late August and early September. The analysis of the data collected from this group is underway.

COOPERATIVE MARKETING
Farmer Cooperative Service

Problem: Farmers are expanding their use of cooperative marketing. There are constant changes in transportation, processing, and distribution technology, and in market organization and practices, and changes on the farm itself. In view of these developments, farmer cooperatives and other marketing firms require research results to perform both efficiently and effectively. Such research can assist farmers to maintain and strengthen their bargaining power, increase efficiency, and meet the quality, quantity, and service needs of today's food and fiber marketplace.

Cooperative marketing is a major way for farmers to get maximum returns from their products in the current and rapidly changing market. Farmers own and control cooperatives specifically to increase their income from crops and livestock. Gains are not automatic, however. Cooperatives must plan, develop, and actually manage the specific marketing program and services that will yield the most for their members. Marketing cooperatives must know what the market demands. They must be able to compute the probable cost of different ways of serving the market. They must understand the possibility of major economies in a well coordinated joint sales program, and understand the methods and potentials of bargaining. Management must achieve minimum costs through improved organization, good use of existing plant and personnel, and the selection and use of new equipment and methods.

USDA PROGRAM

The Department conducts a continuing long-range program of basic and applied research and technical assistance on problems of marketing farm products cooperatively. Studies are made on the organization, operation, and role of farmer cooperatives in marketing. While most of the research is done directly with cooperatives, the results are generally of benefit to other marketing firms. The work is centered in Washington, D.C. Many of the studies, however, are done in cooperation with various State experiment stations, extension services, and departments of agriculture.

Federal professional man-years devoted to research in this area totaled 23.3. Of this number, 1.0 was devoted to cooperative marketing of citrus, 2.7 to cotton, 4.5 to dairy, 1.2 to deciduous fruit, 2.2 to grain, 3.9 to livestock and wool, 1.3 to oilseeds and peanuts, 1.0 to potatoes, 3.5 to poultry, 0.1 to rice, 0.6 to tobacco, and 1.3 to vegetables.

Research also is conducted under contract with land-grant colleges, universities, cooperatives, and private research organizations. During the period of this report, contract research was performed by universities and colleges in Florida, Iowa, Louisiana, Montana, North Dakota, and West Virginia, and by one private research company.

STATE EXPERIMENT STATIONS PROGRAM

The State stations maintain a very broad research program in commodity marketing, the findings of which are valuable to cooperatives and to other marketing firms. There are at this time nine projects in eight States that deal specifically with cooperative marketing. Five projects are commodity oriented and deal with grain, tobacco, milk, livestock, and fruits and vegetables. These projects seek to find out how cooperatives are adjusting or might better adjust to changes in market structure and marketing practices. In some instances researchers are studying the success and failure of cooperatives and the organizational structure. One study of the history of major cooperative marketing associations in the State will be published as a book and will undoubtedly receive nationwide attention.

Because of the growing interest in the role of cooperatives in market structure, one State recently initiated a major project in this area. The project leader views cooperative enterprises as a structural dimension of farm markets. The objectives and operating procedures of cooperatives will be studied to see if they have a unique impact upon market conduct and performance. If so, this may have significant implications for Government policies and programs.

The total research effort on cooperative marketing in the eight States is 3.4 professional man-years.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Potentials in cooperative marketing

In several commodity areas an appraisal is needed of the present and potential role of cooperative marketing. Current information on cooperative operations can be related to production and marketing conditions. This research will yield suggestions about cooperative operations and services, and provide current data needed by cooperative leaders and others for planning and implementing cooperative marketing programs.

Livestock. Trends in consumption and the market potential for meat in the Northeast were studied on a regional basis. Several concerns were contacted in the region that buy meat for additional processing. Preliminary findings indicate that existing and proposed cooperative slaughter plants in the Corn Belt area could find profitable outlets for their members' livestock in the Northeast.

Studies under contract with Montana, North Dakota, and Oregon relating to cooperative feedlots have been completed. These studies indicate possible benefits to livestock growers and grain producers from feeding locally produced animals and crops over selling both the feeder animals and grain.

B. Improving operating methods in processing and storage

Studies were underway in several commodity fields to examine new methods, equipment, facilities, and structures for efficient and safe processing and storage of agricultural products by cooperatives.

Livestock. Three livestock marketing cooperatives were studied to find ways such cooperatives might increase their volume by attracting large producers, thus reducing operating costs.

C. Cost and efficiency

Research studies were undertaken to develop more efficient marketing practices and procedures through analysis of costs involved in using various kinds of facilities and methods of operation.

Livestock. Analysis was made of the feasibility of livestock producer cooperatives integrating their operations from production through feedyards, marketing, processing, and distribution. Information was provided several groups about one or more phases of handling livestock.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Fox, R. L. 1964. Service--The Merit Basis for Livestock and Wool Co-ops. News for Farmer Cooperatives (Jan.).

Lantz, F. 1964. Grade and Price Differentials Improve Hog Marketing. News for Farmer Cooperatives (May).

MARKET STRUCTURE, PRACTICES, MARGINS, COSTS, AND EFFICIENCY
Marketing Economics Division, ERS

Problem: The purpose of this research is to find solutions for economic problems in marketing dairy, poultry, and meat animals and their products. More specifically, it is to find answers to the needs of farmers, marketing agencies, and the public for economic knowledge about these commodities--needs for economic knowledge that is relevant to marketing decisions and to the shaping of public policy and programs. This project includes studies of margins, costs and efficiency; of the structures of the systems for marketing individual products; and of the methods and practices followed by farmers, marketing firms, and related public agencies. It provides accurate information about the form and working of the marketing system as a basis for initiating desirable changes and for keeping all parts of the system abreast of technological and economic progress.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program of economic research to assist farmers and marketing agencies to adapt to changes in the environment in which they operate. Work in this area is conducted at Washington, D. C. and in cooperation with State agricultural experiment stations at Durham, N. H., Athens, Ga., St. Paul, Minn., Ames, Iowa, Fort Collins, Colo., Stillwater, Okla., and College Station, Texas. The Federal scientific effort devoted to economic research in this area totals 33.3 professional man-years, distributed as follows: dairy 10.0, swine 0.4, beef 0.5, livestock (cross-commodity) 10.7, and poultry and eggs 11.7. By functional areas, it is distributed as follows: structures, practices and competition 15.0, product quality 3.1, information, outlook and rural development 0.7, and margins, costs and efficiency 14.5.

PROGRAM OF STATE EXPERIMENT STATIONS

All the State experiment stations are conducting economics research dealing with the marketing of animals and animal products.

Livestock marketing research deals with the economic problems involved in the marketing of beef, swine, sheep and wool. The major part of the work is in the areas of structures, practices and competition; merchandising and promotion; product quality; margins, costs and efficiency and transportation. Four regional livestock marketing projects are underway. NCM-25 investigating needed adjustments in production relative to prospective demand and is determining the effect of production, consumption and transportation costs upon market structure. WM-39 is designed to show the nature and extent of

direct marketing, and costs and returns from different methods of marketing. WM-48 is concerned with the market organization of the livestock industry in the West and is studying Western and Central markets for feeder and fed cattle and the volume-cost relationships for meat distribution. SM-23 is investigating meat and livestock movements and the role of transportation cost regarding the location of livestock production and processing facilities.

The State effort devoted to livestock marketing research amounts to 32.02 professional man years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Product Quality

1. Hog Grading and Pricing. The ultimate volume of live hogs purchased for slaughter is determined by their actual yields of salable cuts, although customarily live hogs are priced on the basis of buyer estimates of yield, usually based on a general relation to liveweight. Variability in actual yield among individuals' lots, weight ranges, and other factors suggest that more accurate pricing practices could be developed if relation of various factors associated with variation in yield were measured.

Analysis showed that 94 percent of the variation in value among carcasses was explained by variation in weight of carcass and weight of four lean cuts as percent of carcass weight. Equations were developed showing relations between weight, length and backfat thickness, and yield of lean cuts.

On this basis, suggested pay-price differentials were developed (a) between grades (b) with various changes in relative prices of pork cuts.

B. Structure, Practices, and Competition

Simulation of Pricing and Marketing Livestock. Alternative pricing and trading strategies were incorporated into a computer model of the livestock-meat economy, and the prices and outputs under these alternative structures were simulated over both the historical and projection periods. Three forms of wholesale-to-retail margin strategies were simulated--a constant percentage markup, a semi-variable markup containing both a fixed component and a percentage markup component, and a fixed markup which varied with the price index. The variable margin strategy is preferable to the fixed margin inasmuch as the fixed margin restricts output and shows more extreme price cycles. The variable markup (percentage markup) produced a lower average wholesale-to-retail margin than either the semi-variable or fixed margin strategy.

Both a fixed (1958-62 average) and a 4 percent limitation on net foreign trade in beef reduced net imports from 40 to 60 percent. Trade limitation increased the amplitude of the price cycle, but raised average wholesale beef prices approximately one dollar per hundredweight over the 11-year projection period. However, average per capita beef consumption was about one pound lower during the 1964-75 period. This raised the average Choice grade steer price 75 cents over the projection period. Pork prices and per capita consumption of pork were not affected to any significant extent.

A "product utilization control" strategy which maintained a target per capita consumption rate with a two-price system for beef and pork essentially eliminated the price and output cycle. Wholesale beef and pork prices averaged one dollar higher than the historical structure projection in the 1964-75 simulation, and per capita consumption was also slightly higher. However, the Nation would be a major exporter of pork under such a program.

Under the assumption that the 30 day producer holding action lowered the 6 month average price substantially due to the increased marketings of the following 60 days, the long-run effects over the following 9 years showed total production to be about the same with slightly lower prices. The amplitude of the beef and pork price cycles was increased. The buildup in the cattle cycle, as measured by January 1 inventories, was held down for several years. The major result of this simulation is to show the nature of the long-run effects associated with a major short-term market change.

C. Margins, Costs and Efficiency

1. Marketing Costs and Margins. Changes in price spreads for beef consisted of two parts: Short-run fluctuation and long-term trend. The short-term changes were associated closely with the lag between adjustments in farm and retail prices. The long-term trend was persistently upward at a greater rate than spreads for other meats have increased, and at a greater rate than present indicators of retailer costs or the consumer price index. A possible explanation of this trend is a change in retailer pricing policies which shifts overhead from other commodities to beef.

Meatpacker costs for slaughtering hogs and distributing fresh pork averaged about 3 1/2 cents for wholesale pound output for two quarters in 1962-63. Total costs did not differ appreciably with changing volume, in two quarters, for this sample. About two-fifths each of total labor cost was for killing hogs and cutting carcasses; the remainder for over-filling and shipping room expense. Costs for curing and smoking hams, bacon and picnics amounted to an additional 5 to 15 cents per pound of cured and smoked product.

Meatpacker costs for slaughtering and distributing fresh beef per wholesale pound averaged about 3.1 cents for plant costs and an additional 1.1 cent for shipping to distribution centers and local delivery.

2. Economies of Scale in Meatpacking. The analysis indicated that average cost of slaughtering cattle decreases slightly as plant size increases from 20 to 60 head per hour and increases slightly for plants designed to operate, with a single shift, at line speeds of 75, 90, and 120 head per hour. The average cost estimates for operation at rated line speed were $6.96 per head for the 20 head per hour plant, $6.86 per head for the 40 per hour plant, $6.50 per head for the 60 per hour plant, $6.65 per head for the 75 per hour plant, $6.72 per head for the 90 per hour plant, and $6.89 per head for the 120 per hour plant.

Short-run average costs increased for each size of plant as output increased from 90 to 115 percent of rated line speed. Over the range of plant sizes studied, the average cost decreased an average of $.47 per head as plant output increased from 90 to 115 percent of rated line speed.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Agnew, D. B. December 1963. Meat packers' costs: Recent interest, methods of analysis and implications. Jour. Farm Econ. 5 pp.

Fishel, W. L., Dubov, Irving, Rohdy, D. D., and Stout, R. C. January 1963. Hog and pork movement in the Southeast. Southern Coop. Service Bul. 83. 97 pp. and Statistical supplement No. 2. 80 pp.

Rohdy, D. D. December 1963. Southeast hog-pork industry: A national market competitor. Southern Coop. Ser. Vul. 89. 96 pp.

COMMODITY SITUATION AND OUTLOOK ANALYSIS
Economic and Statistical Analysis Division, ERS

PROBLEM

Because of the instability of the prices he receives and rapidly changing conditions of agricultural production, the farmer stands in special need of frequent accurate appraisals of his economic prospects if he is to plan and carry out his production and marketing activities in an efficient and profitable way. The typical farmer cannot afford to collect and analyze all the statistical and economic information necessary for making sound production and marketing decisions. It is a goal of the Department to provide the farmer with economic facts and interpretations comparable to those available to business and industry. This is accomplished through a continuous flow of current outlook information, the development of longer range projections of the economic prospects for agricultural commodities, and analyses of the economic implications of existing and proposed programs affecting farm commodities.

USDA AND COOPERATIVE PROGRAM

The program includes the regular publication of 12 commodity outlook reports; holding of the Annual Outlook Conference in Washington in mid-November; participation of commodity specialists at regional and State outlook meetings and at meetings of farm organizations and agricultural industry groups; preparation and publication of special articles bearing on both the short-run and long-run outlook for farm commodities; issuance of comprehensive statistical bulletins containing the principal economic series pertaining to the various commodities; long-range projections of supply of and demand for the major agricultural commodities; and continuing analysis of the impact of existing and proposed alternative farm programs as they affect output, utilization, and prices of these commodities.

Except for a Regional Field Office for Livestock, in Denver, Colorado, all the USDA situation and outlook work is carried on in Washington. The regional livestock project is a cooperative effort including the Economic and Statistical Analysis Division, the Federal Extension Service, and State Extension Services in the Western and certain Great Plains States.

The total USDA commodity situation and outlook program currently involves 21.5 professional man-years.

(a) Livestock and Meat. This work involves 2.5 professional man-years in Washington and 2.0 professional man-years in Denver, Colorado. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of livestock and meats. These appraisals, developments of interest to the industry, and results of special studies

are published 6 times a year in regular issues of the Livestock and Meat Situation, in special additional issues as warranted, quarterly in the Demand and Price Situation and the National Food Situation, and monthly in the Western Livestock Round-Up, which is supplemented by special releases and materials circulated to Extension Marketing Specialists in the cooperating Western and Great Plains States. A comprehensive analysis of the livestock situation is presented at the Annual Outlook Conference. Outlook appraisals are presented at regional and State outlook meetings, at meetings of farm organizations, and to various agricultural industry groups. Special analyses are prepared on the probable effect of proposed feed grain programs on the price, supply and consumption of livestock and livestock products. Basic statistical series are maintained, improved and published for general use in statistical and economic analysis. A Statistical Handbook, Livestock and Meat Statistics is published annually.

(b) Fats and Oils. This work involves 2.0 professional man-years in Washington. The outlook and situation program provides a continuing appraisal of the current and prospective economic situation of fats, oils, and oilseeds. These appraisals, developments of interest to the industry, and results of special studies are published 5 times a year in the Fats and Oils Situation, quarterly in the Demand and Price Situation and the National Food Situation, and occasionally in monthly issues of the Farm Index and the Agricultural Situation. A comprehensive analysis of the fats and oils situation is presented at the Annual Outlook Conference, and more limited appraisals are given at meetings with industry groups. Special analyses are prepared on the probable effect of proposed programs on the acreage, price, supply, and demand for oilseed crops and for fats and oils and their products. Basic statistical series are developed, maintained, improved and published for general use in statistical and economic analysis. A Statistical Handbook, Oilseeds, Fats and Oils, and Their Products, 1909-63, is being revised and updated for publication in the fall of 1965.

PROGRAM OF STATE EXPERIMENT STATIONS

For the most part the States depend upon the U.S. Department of Agriculture for the yearly across-the-board commodity situation and outlook research. The State extension staff members supplement and adapt such research information to meet the commodity situation of their States.

Four States have projects that deal specifically with analysis of current price trends and prediction of future prices. There is increasing interest in longer range price prediction because of the growing specialization of farms, which make yearly enterprise shifts less common and less feasible, and which calls for large capital commitments over longer periods of time.

The total direct research effort in the situation and outlook area is approximately 1.7 professional man-years. While not designated as outlook research, much of the research conducted by the experiment stations and reported elsewhere contributes to improved understanding of price-making forces, which in turn improves market situation analysis and price forecasting.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

Livestock and Meat

In addition to the regular situation and outlook work, several special analyses were made. Attention was given to the cattle cycle which began its current buildup phase in 1959. Major factors considered were the length of the various cycles, the rate of buildup, and the effects of increased feedlot feeding on the present cycle. An analysis was made of average live weights of slaughter cattle and the relative price differentials between grades as steer and heifer beef production is increased. With the movement toward larger cattle feeding operations, an evaluation was made of the significance of changing seasonal placement patterns. Because of relatively low prices, particularly for fed cattle, special analyses were made of alternative USDA purchase programs and their effects on price and producer returns.

A study was made of U.S. foreign trade in livestock and livestock products, and results were published in the May issue of the Livestock and Meat Situation report.

Further attention was devoted to appraising the profitability of alternative feeding programs--short fed versus long fed. In addition, an analysis was made of the hog-corn price ratio through time. This analysis indicated that as labor and other costs advance the ratio is becoming a less reliable indicator of farrowings than in earlier years.

PUBLICATIONS--USDA AND COOPERATIVE PROGRAMS

Livestock and Meat

Rojko, A. S. Livestock and Meat Situation. Published 6 times a year. ERS, USDA, Washingtion, D. C.

Hannawald, E. B. July 1964. Relation to hog slaughter to pig crops. Livestock and Meat Situation, pp. 28-33.

Rockwell, George R. Jr. May 1964. U.S. foreign trade in livestock and livestock products. Livestock and Meat Situation, pp. 18-38.

Thompson, John W. January 1964. Hide and leather situation brighter in 1964. Livestock and Meat Situation, pp. 26-28

Thompson, John W. July 1964. Recent changes in hide marketings. Livestock and Meat Situation, pp. 34-37.

Livestock and Meat Statistics, August 1964. Supplement for 1963 to ERS Statistical Bulletin No. 333, 162 pp.